# HARTFORD AREA TRAFFIC STUDY



Volume 1

HATS

July, 1961

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# HARTFORD AREA TRAFFIC STUDY REPORT

VOLUME I

PREPARED BY
PLANNING RESEARCH UNIT
DIVISION OF PLANNING
CONNECTICUT HIGHWAY DEPARTMENT
IN COOPERATION WITH
THE BUREAU OF PUBLIC ROADS
UNITED STATES DEPARTMENT OF COMMERCE

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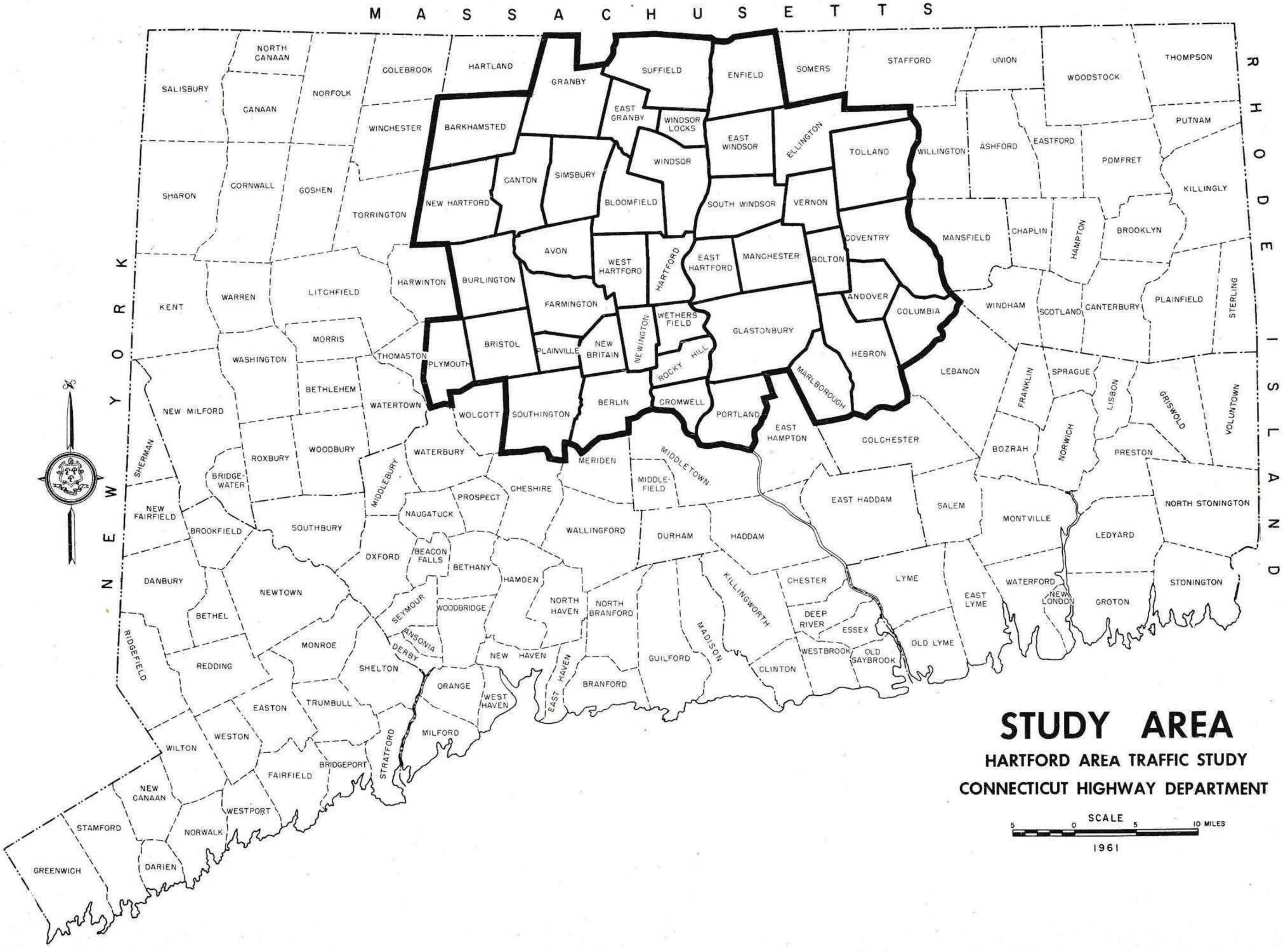
## I. INTRODUCTION

In 1959 the Connecticut Highway Department, in cooperation with the City of Hartford and the Bureau of Public Roads, undertook a traffic study for the purpose of analyzing present and future travel and capacity needs of the Greater Hartford Area. The scope of this study required the use of more comprehensive methods than had previously been used in Connecticut and more advanced techniques than the generally accepted practice. The Automotive Safety Foundation agreed to provide the services of Mr. Alan Voorhees to aid in the development of the methods and proceedures used for the study. During the course of the study the Capitol Region Planning Agency was formed and in 1960 entered the study as a full participant.

The Hartford Area, for purposes of this study, covers 1078 square miles, approximately 22% of the State of Connecticut. The 1960 population of the study area according to the 1960 census is 752,200, approximately one-third of the State population. Of the 41 separately incorporated towns in the study area, as shown in Figure I, Hartford, with a 1960 population of 160,500, is the largest single community, and with the exception of the Bristol-New Britain complex, forms the central core of the area.

The problem at hand was that of producing an accurate, logical prediction of the traffic movements in future years. The single most influential factor in the study was population growth. Because the increase in population stimulated an increase in car ownership and trip production, the projection of population growth and its proper distribution throughout the area was the most critical determinant in establishing the distribution of vehicular trips between the various zones. Other fac-




# STUDY AREA

## HARTFORD AREA TRAFFIC STUDY

## CONNECTICUT HIGHWAY DEPARTMENT

SCALE

5 0 5 10 MILES

1961

FIGURE I

tors found to be important in the control of area growth and distribution were combined to produce an effective basis for projection.

Emphasizing the importance of this distribution, the study consists basically of four phases: (1) the Population Projection, (2) the Land Use Analysis, (3) the Traffic Analysis, and (4) the Assignment.

## II. BACKGROUND AND DESCRIPTION

### A. Population Projection

The basis of trip production for the study is car ownership which is related directly to population. Therefore, the value assumed for the future population is of extreme importance for it sets the scale of values for the entire study. For this reason, considerable analysis was given to determining a realistic value for the future population.

Because of the difficulty of accurately extrapolating a past trend curve, such as population, it is customary to project a high and a low point for the future and choose the mid-point between these as the best estimate for the future population. Also, since it is possible to predict future values for large areas with greater accuracy than for small areas, most of the past trend analyses were made for the Statewide population, and then converted to the study area value by taking the appropriate percentage of the statewide prediction.

### B. Land Use Analysis

The most significant development resulting from HATS is the method of land use analysis which was developed during the course of the study. This was made possible only through the close cooperation maintained throughout the study between the Highway Department and the city planners, both the City of Hartford and the Capitol Region Planning Agency.

Past methods of traffic analysis have been somewhat deficient in the land use forecasts. Since, in the final analysis, it is the future land use and intensity of land use which determines the future traffic, any study of traffic in order to produce realistic results must, of necessity, be based on an extensive land use study.

Briefly, the land use analysis is based on a mathematical model, which could be termed an "Accessibility Model", in which one area is compet-

ing with every other area for its growth. Actually, highway accessibility is only one of many factors which influence future growth. On the basis of multiple correlation analyses and other similar means, many of the factors involved in metropolitan growth were determined and these factors were then used to rate each of the highway zones. Distributions of the future growth were then based upon these ratings.

C. Traffic Analysis

Since its early beginning, the field of traffic estimation has developed in three basic and somewhat distinct steps. The first, in the 1920's, was the development of procedures related to traffic counting and later the statistical techniques required to expand these counts. As the field of traffic engineering developed, it was recognized that traffic counts alone could not accurately predict the actual movements of traffic. To improve the methods of traffic estimation the second step appeared. The origin-destination survey was developed in the late 1930's. This method, with its various forms of roadside, postcard, and home interview surveys, has served well. However, for some time traffic engineers have recognized the shortcomings of predicting future traffic on the basis of existing origin-destination movements.

The third step in this evolutionary process came in the 1950's with the development of several mathematical models aimed at overcoming the shortcomings of the older methods. Of these new methods, the principal ones are: (1) the Fratar Method, (2) the Gravity Model, as developed by Alan Voorhees, and (3) the Opportunity Model or Method of Intervening Opportunities, developed during the Chicago Area Transportation Study. Each of these methods has its own particular advantages and shortcomings. It is felt by the Connecticut Highway Department that the assumptions used for the Gravity Model and their applications are most realistic and straightforward.

The Gravity Model derives its name from the fact that vehicle trips are distributed by a formula which closely resembles Newton's formula for the law of gravity. Newton's law states that objects attract each other with a force proportional to the mass of the objects and inversely as the square of the distance between them. Similarly, the Gravity Model formula distributes vehicle trips in proportion to the drawing power of an area, which represents the mass, and inversely as some power of the distance between the areas. The distance is usually measured in terms of travel time rather than miles.

The actual formula can be expressed by the following equation:

$$\text{Trips}_{AB} = \text{Trip Production}_{A} \times \frac{\text{Trip Attraction}_{B} \times \text{Travel Time Factor}_{AB}}{\sum_{A}^{n} (\text{Trip Attraction} \times \text{Travel Time Factor})}$$

It is likely that the term "gravity model" would have been different if it had been conceived in the field of traffic in the mid-thirties. In that era it would have been described as a means of estimating the distribution of future traffic by use of mathematical formulae. However, in the contemporary field of science the term "model" is used to describe both simulation and miniature prototyping. The Gravity Model then is a method of depicting present and future traffic patterns through the use of mathematical formulae.

D. <u>Traffic Assignment</u>

A significant development in traffic analysis has been the network assignment which was made possible through the development of high speed computers and the "tree building program".

The tree building process is used to develop interzonal travel times from the centroid of each zone to every other zone centroid, as well

as to record the path or route through the street and highway network which a trip between each pair of centroids would follow. Whereas this process is extremely complex and represents the key to many phases of the process, it is probably the least controversial of all the processes. Perhaps the most critical function of the tree building program is in the traffic assignment phase. When the tree is developed by the computer, the path or route used for the trip is stored in the computer memory for future use in the assignment program. Once these trip traces are determined they can be used to assign origin-destination volumes determined from any type of traffic analysis.

## III. STUDY PROCEDURES

### A. Projections

#### 1. Population

Any projection procedure must be based upon the extrapolation of past trend data, whether this data be traffic, population or other. More stable past trend data will result in a smaller error in the future estimate, and from this develops the first of many advantages of HATS. Figure II shows the past growth of: (1) population, (2) individual income, (3) registration, (4) motor fuel consumption, and (5) driver licenses for the State of Connecticut.

It will be noted that, by comparison, the population curve shows a much smoother growth. This curve rises continually, comparatively steadily, year after year. Therefore, extrapolation of this curve should result in a much closer estimate for the future than an extrapolation of the other factors portrayed which are affected by a temporary condition such as war, and by economic fluctuations induced by inflations, depressions, recessions and times of prosperity.

Figure III illustrates four population projections to the year 1975. The 1950 Connecticut Development Commission (CDC) estimate shows a 1975 population of approximately 3,140,000. Two things are apparent from this projection: (1) the CDC estimate for 1960 is considerably below the actual 1960 figure, and (2) the future estimate is based upon a straight line extrapolation of the semi-log plot for the decade from 1940 to 1950.

This estimate was made before the 1960 census information was available, which accounts for the fact that the 1960 value is considerably below the actual figure. Nevertheless, some valuable information can be derived from this prediction. Although some authorities advocate that the normal population growth follows a straight line on a semi-log plot, for the

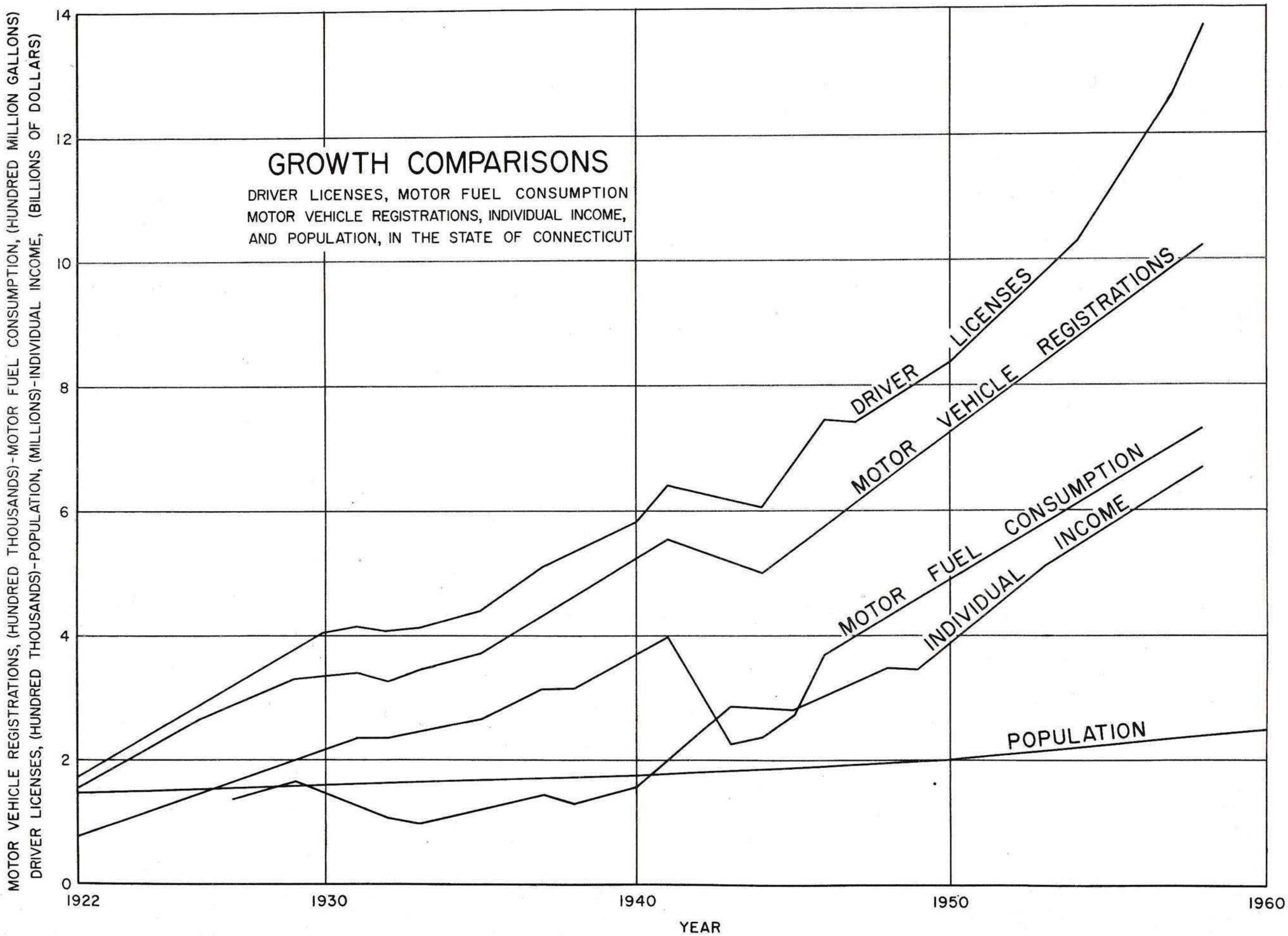

GROWTH COMPARISONS
DRIVER LICENSES, MOTOR FUEL CONSUMPTION
MOTOR VEHICLE REGISTRATIONS, INDIVIDUAL INCOME,
AND POPULATION, IN THE STATE OF CONNECTICUT
DRIVER LICENSES
MOTOR VEHICLE REGISTRATIONS
MOTOR FUEL CONSUMPTION
INDIVIDUAL INCOME
POPULATION
MOTOR VEHICLE REGISTRATIONS, (HUNDRED THOUSANDS)-MOTOR FUEL CONSUMPTION, (HUNDRED MILLION GALLONS)
DRIVER LICENSES, (HUNDRED THOUSANDS)-POPULATION, (MILLIONS)-INDIVIDUAL INCOME, (BILLIONS OF DOLLARS)
0
2
4
6
8
10
12
14
1922
1930
1940
1950
1960
YEAR

FIGURE II

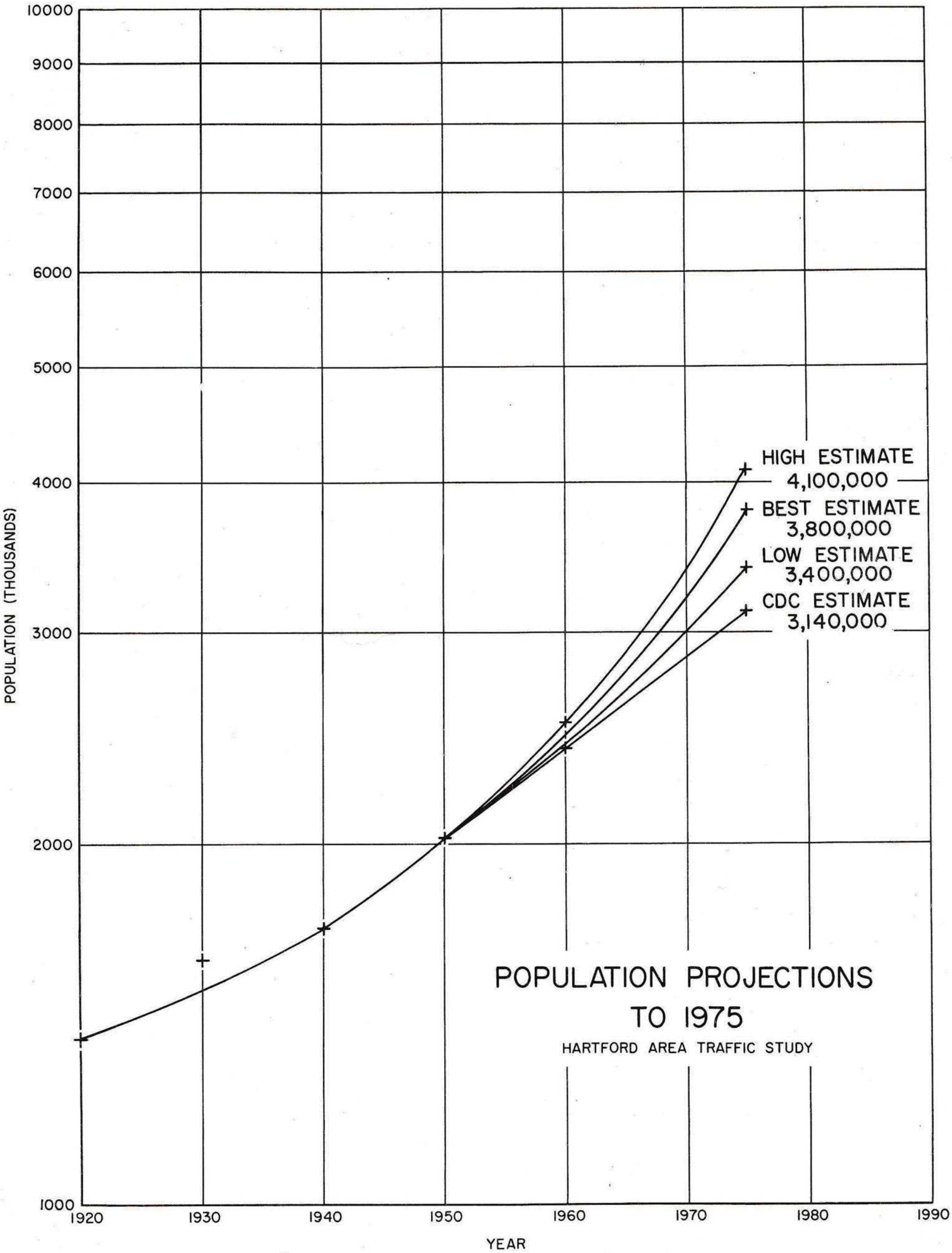

10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
POPULATION (THOUSANDS)
HIGH ESTIMATE
4,100,000
BEST ESTIMATE
3,800,000
LOW ESTIMATE
3,400,000
CDC ESTIMATE
3,140,000
POPULATION PROJECTIONS
TO 1975
HARTFORD AREA TRAFFIC STUDY
1920
1930
1940
1950
1960
1970
1980
1990
YEAR

FIGURE III

State of Connecticut it is rather obvious that this has not been the case. For every decade, except 1930 to 1940 (the depression era), each succeeding decade has produced faster growth than would be predicted on this basis. For this reason alone, such a method would produce a good estimate for the low value sought.

A second method, used to predict a high estimate, would be to fit a curve to the actual population for the past 40 years and extend this curve for the projection period. Values at great variance from others (e.g., 1930) should be disregarded. As illustrated on Figure III, this produces a 1975 estimate of 4,100,000.

Considering the high and low estimates, it is possible to predict a reasonable value for the 1975 statewide population: 3,800,000. This estimate is higher than the results of other predictions for the State primarily because it is based on the higher-than-anticipated 1960 census figures, whereas other available estimates used the 1950 census as a base.

Having arrived at a reasonable Statewide population prediction, it was necessary to determine the percentage of the statewide population residing in the study area in 1975. This was accomplished through an investigation of past trend data in the study area. Shown in Figure IV is the percentage of the statewide population within the area for the past 40 years. It is seen that for this period the percentage of the State population that was located within the study area has risen constantly, and except for 1930, this increase has been exceptionally constant. Projecting this rate of increase to 1975 indicates that in that year 31.3% of the State population will live within the study area. This, then, is the information necessary to calculate a 1975 population for the study area: 3,800,000 x 0.313 = 1,189,000.

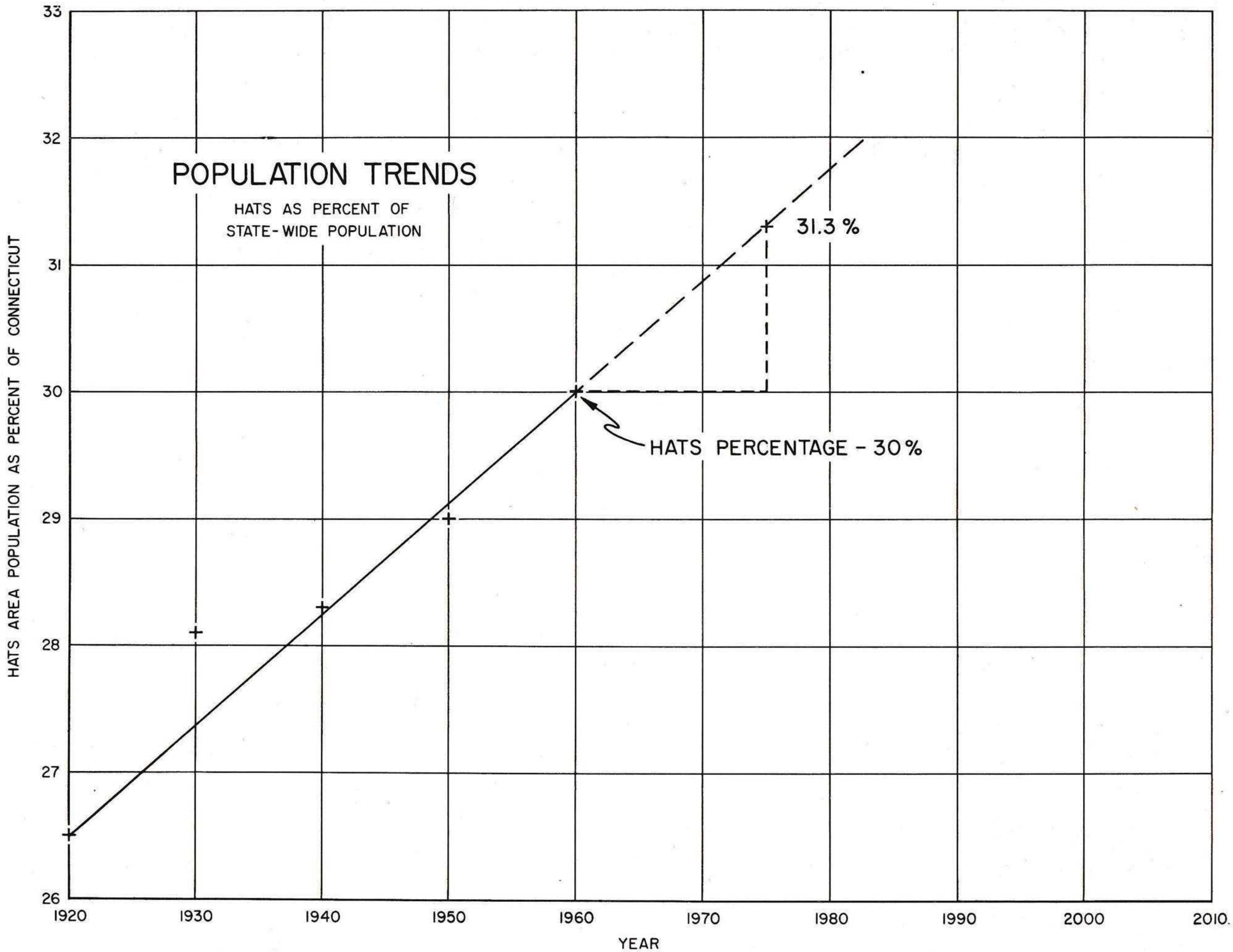

POPULATION TRENDS
HATS AS PERCENT OF
STATE-WIDE POPULATION
31.3 %
HATS PERCENTAGE - 30 %
HATS AREA POPULATION AS PERCENT OF CONNECTICUT
33
32
31
30
29
28
27
26
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010.
YEAR

FIGURE IV

Although the value of 1,189,000 is perhaps the most realistic estimate for the 1975 population, in order to insure a conservative appraisal of future traffic, the low limits were used; 3,400,000 for the Statewide population, and 30% for the conversion from Statewide to the study area. Thus, the 1975 study area population is assumed to be 3,400,000 x 0.30 = 1,020,000.

It is noted that the major control for the entire projection analysis of HATS is the population projection and the extrapolation of the population curve to the various design years. The projection process was developed around this concept to avoid the apparent difficulties involved in attempting to estimate future traffic on the basis of the other curves shown which do not have the same stability. From the estimate of future population it is possible to determine with a high degree of accuracy the other constants needed for the traffic estimates. These include: (1) Total Employment, which has historically been a constant percentage of the population, (2) Labor Force, which must equal the Total Employment, and (3) Car Ownership, which is derived from the population as discussed later.

2. Employment Forecast

The increase in total employment for each time period was handled by assuming that 40% of the population increase would be in the labor force. With the establishment of future total employment, the categories of manufacturing, service, and retail employment were obtained by taking 50% for manufacturing, 32% for service employment, and 18% for retail trade employment. Table 1 shows past trends for these percentages and, as can be seen, the 1975 predictions which have been used are similar to those presently indicated.

TABLE 1

COMPARISON OF EMPLOYMENT TRENDS
IN THE HARTFORD AREA

| Year | Manufacturing | Service | Retail |
|---|---|---|---|
| | Percent of Total Employment | | |
| 1948 | 51.0 | 33.0 | 16.0 |
| 1955 | 48.0 | 35.0 | 17.0 |
| 1960 | 49.0 | 33.0 | 18.0 |
| 1975 | 49.0 | 33.0 | 18.0 |

A further analysis of total employment and population data demonstrated that total employment will increase at least 3% more than the population for HATS from 1960 to 1975, while economists predict that total employment nationwide will increase on an average of 4% faster than population from 1960 to 1975. The use of 3% is contrary to actual figures. For Connecticut as a whole, the increase is above the national average, and the Hartford area is growing faster than the State as a whole. Consequently, the future traffic estimates are on the conservative side.

B. Land Use Analysis

Actually, it is not the determination of the total values of population, employment, labor force and car ownership which presents the major problem. Rather, it is the future distribution of these totals which causes the most concern. Whereas the total population produces the traffic, it is the distribution of this total, together with the location of employment and shopping opportunities, which determines the future traffic volumes and patterns. It is this phase of the projection process, perhaps the most important phase, which has until recently received the smallest percentage of the total effort.

1. Land Use Model

During the study, a method was developed by which the future distribution of people and employment can be estimated with a high degree of accuracy. It was further proven that metropolitan areas do grow as the result of rational decisions made by individuals which, when grouped together as a whole, can be predicted on the basis of mathematical formulae.

Unlike the traffic analysis which includes information and techniques which have been widely used and tested, the land use analysis developed was for the express purpose of this particular study. The purpose of the land use analysis was specifically to provide land use information for the Gravity Model and the techniques and information developed were aimed strictly toward that end.

The study of the land use trends was based generally on an analysis of past growth between 1947 and 1958. On the basis of this growth assumptions were made for the factors influencing the trends, and then these assumptions were tested to check their validity and reliability. In this way the relative importance of the many factors involved was checked, and for projection into the future, these weights were varied to adjust for changing trends.

The first task in this study was to determine which categories would be included in the analysis or, more basically, which types of employment should be studied separately. In order that a workable procedure be developed it was necessary to keep the categories at a minimum, and to group the categories by similar characteristics.

Therefore, it was determined that population growth would be handled as a single factor. Employment, however, was divided into a number of types, grouped by their particular characteristics. A pilot study, made by the City of Hartford within the three major employment towns:

Hartford, West Hartford, and East Hartford, showed that at least three types of employment must be studied separately -- manufacturing, retail, and service. The last category includes all types not covered by the first two. This was found to be a very realistic breakdown since each of the three groups includes characteristics distinct from the others. For example, manufacturing employment (industry) may be dependent upon rail service, whereas service employment (principally office workers) is relatively independent of it.

The final breakdown of land use for the study was then: (1) population, (2) manufacturing employment, (3) service employment, (4) retail trade employment, and as a by-product, (5) car ownership.

2. Distribution of Manufacturing Employment

The study of manufacturing employment began with a series of multiple correlation analyses in an attempt to determine precisely what variables affect this growth. Ultimately nine variables were used as follows:

a. Highway Accessibility -- that is, the travel time relationship between population and employment at the beginning of the period, as measured by the assumed highway network at the end of the period. This is measured by the following equation:

$$A_1 = \frac{P_1}{T^x_{1-1}} + \frac{P_2}{T^x_{1-2}} + \ldots + \frac{P_n}{T^x_{1-n}}$$

in which A is the accessibility index of a zone to population; P is the zone population at the beginning of the projection period; and T is the travel time between the employment zone and the residential zone as measured by the assumed highway network at the end of the projection period.

b. Availability of Industrial Land or "Holding Capacity" --

the additional acreage in each zone which is available for industrial development.

c. Tax Rate -- reduced to a common base.

d. Sewer Facilities -- primarily a consideration of sewage treatment plant capacity to serve industry and/or the cost of obtaining a satisfactory system.

e. Rail Service -- a subjective rating based on adequacy of service.

f. Water Facilities -- again related to plant capacity.

g. Travel Time to Airports -- there is only one major airport in the area and this rating varied inversely with the travel time from the airport.

h. Promotion -- primarily a measure of the town's activity in promoting industrial development

i. Industrial Land Bordering Expressways -- this rating was obtained by giving a numerical weight of 1.00 to each acre of industrial land within 1/4 mile of an expressway, a weight of 0.50 for acreage between 1/4 and 1/2 mile, and a weight of 0.25 for industrial land between 1/2 and 1 mile of an expressway. The expressway system at the end of the study period was used. This factor is not a measure of highway access but rather a measure of the importance of advertising potential and the prestige of being located near an expressway.

Some of the variables used in this analysis, such as sewer facilities, water facilities, and promotion must be based primarily on subjective judgment. However, most can be rated objectively by numerical analysis. All ratings were reduced to a scale varying from 1 to 50 before they were entered into the multiple correlation equation.

The coefficients developed from the multiple correlation analysis are shown graphically in Figure V. The shaded band represents the coefficient of each variable, this being the relative importance of the various factors. Shown next to each shaded band is a black band which represents the level of significance of each variable. A value of one or more indicates a highly significant correlation (above the horizontal line); below the value of one likewise indicates a questionable significance.

Perhaps the most significant finding from this analysis is that transportation is not the dominant or controlling factor in shaping our cities. With the mobility provided by the automobile, industries have been freed of distance limitations in choice of location and are now able to give more attention to other factors.

From these data it is evident that of prime importance in the location of new industry are availability of land and sewer facilities. Highway access, rail service, and airport access are second in order of importance. Of relatively minor importance are tax rate, water facilities, industrial land bordering freeways, and promotion.

From the formula developed through this analysis it is possible to calculate a growth index for each zone which, when compared to the sum of the growth indices for all zones, represents the percentage of total growth which can be expected in each zone. This formula is as follows:

$$\text{Growth Index} = 12x_1 + 37x_2 + 5x_3 + 34x_4 + 12x_5 + 2x_6 + 19x_7 + X_8 + 5x_9 + 120$$

in which the "x" values represent the magnitude of each of the nine variables described above and the coefficient of the "x" values is the relative importance of that variable, the height of the shaded bars in Figure V.

The true test of an analysis such as this is how closely the formula thus derived can predict the growth of an area. To test this, a

FACTORS INFLUENCING

# DISTRIBUTION OF MANUFACTURING EMPLOYMENT

HARTFORD AREA TRAFFIC STUDY

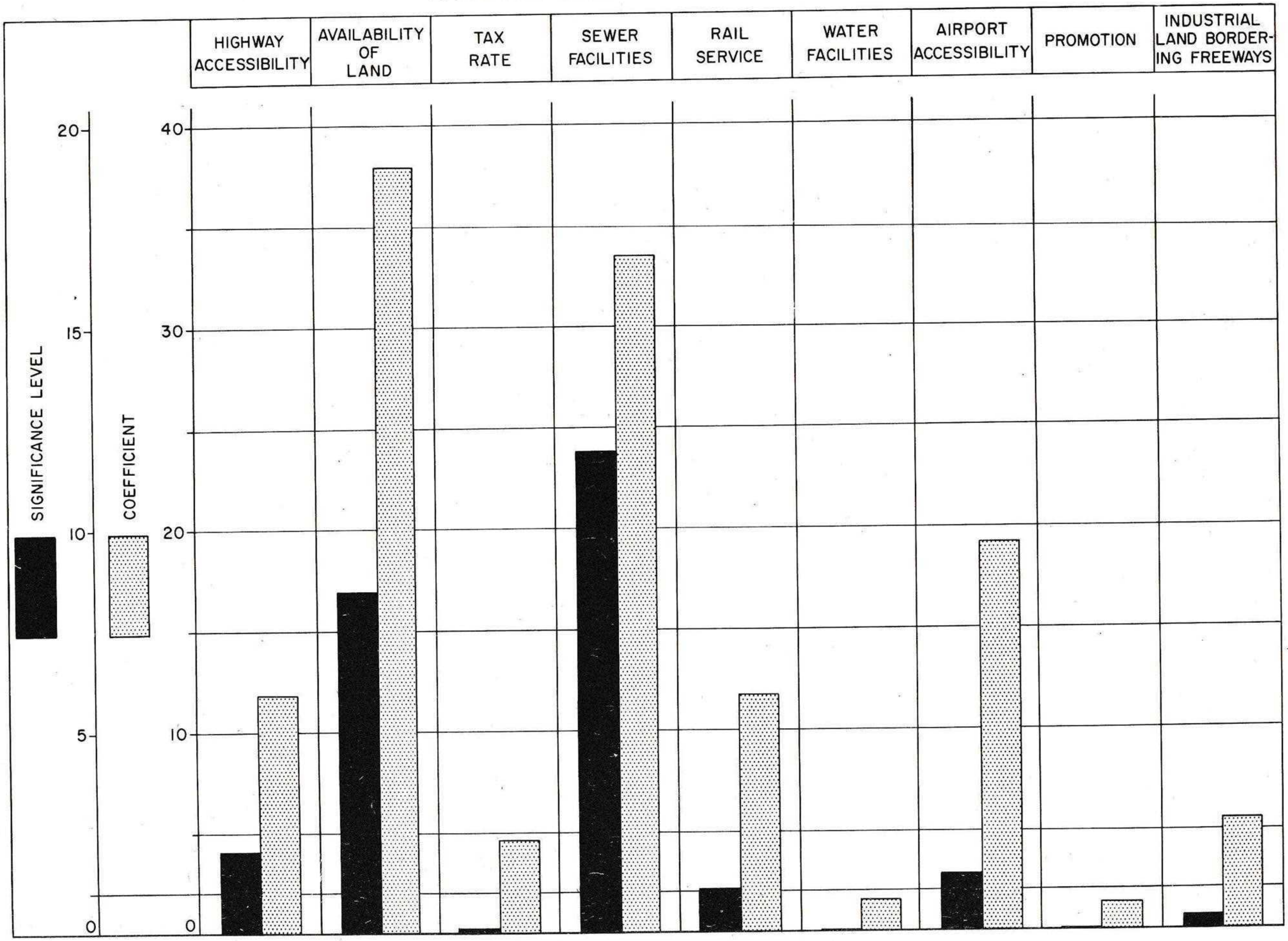



FIGURE V

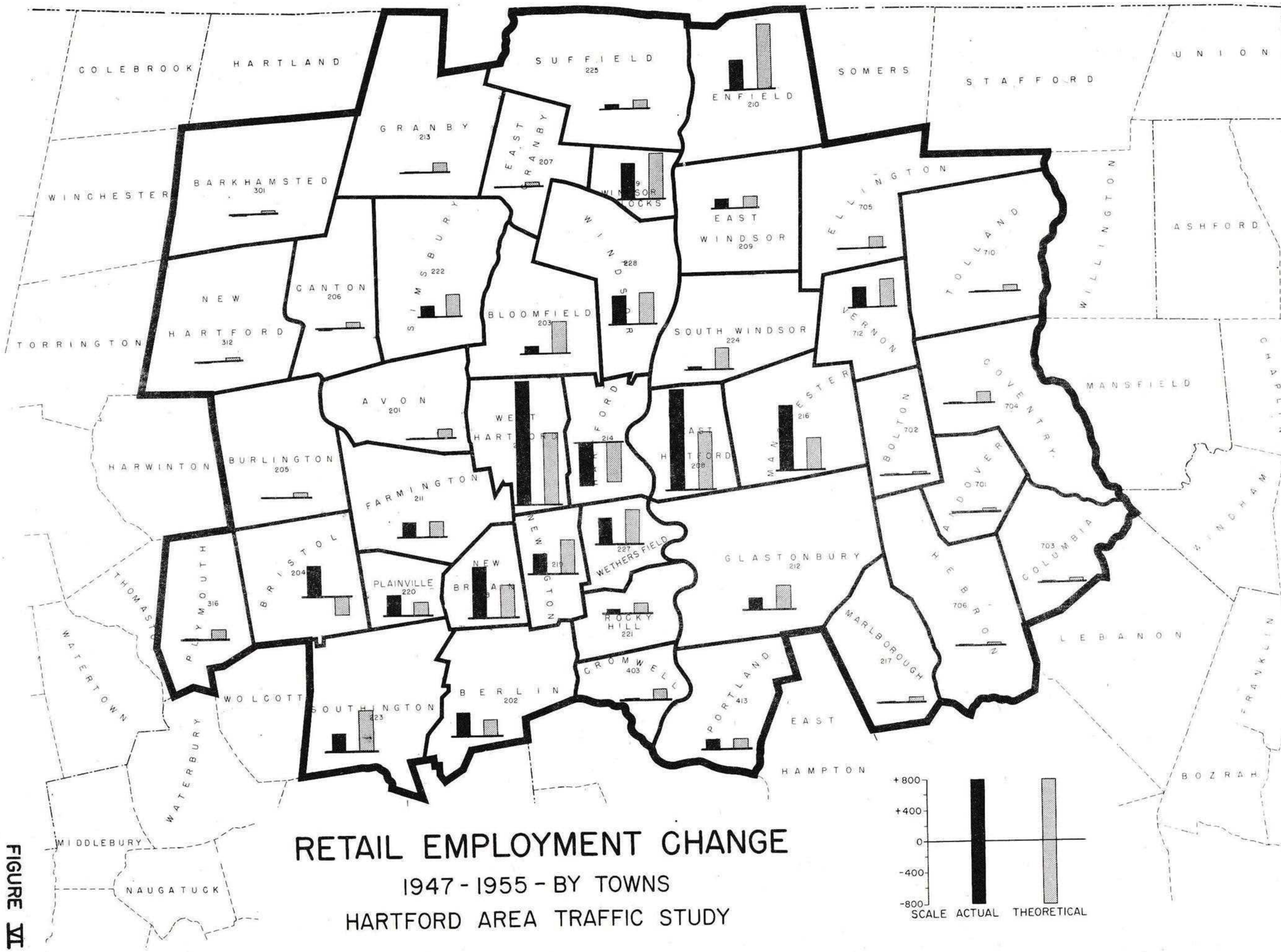
comparison was made of the actual known past growth on a town-by-town basis with the theoretical past growth predicted by the formula. From this comparison it was found that in one more or less continuous corridor the actual growth was considerably higher than the theoretical growth predicted. Inasmuch as this particular corridor was the area where most of the industrial development was occurring, this higher than anticipated growth was attributed to a prestige factor for industrial development. To account for these differences, a ratio of the actual to the theoretical values was taken, then these values were grouped by areas, and the resulting weights were used as adjustments in the formula for future predictions.

3. Distribution of Service Employment

The increase in service employment for a zone was based on the fact that it must be accessible to population and that it generally locates near retail employment areas. Therefore, an index was developed which included both highway accessibility to population and a factor for holding this increase close to the retail areas. The highway accessibility index is the same as was used for the distribution of manufacturing employment in the preceding step. This index was multiplied by the retail trade employment for the preceding period and the product was used as a distribution factor for the distribution of the new service employment.

4. Distribution of Retail Employment

For the study of retail trade employment the hypothesis was made that the future distribution was dependent solely upon the distribution of the new increase in population. This was checked by projecting the increase from 1947 to 1955 on the basis of the hypothesis, and comparing the theoretical distribution thus obtained with the actual growth. The resulting comparison is plotted on a map of the study area and shown as Figure VI. It is seen that generally this is a good check; however,




# RETAIL EMPLOYMENT CHANGE

1947 - 1955 - BY TOWNS

HARTFORD AREA TRAFFIC STUDY

FIGURE VI

some of the towns in the core area have a disproportionate share of the increase, indicating that these may be developing into regional shopping areas.

Although this may be the case, as shown by this comparison, there is no past trend data to support this assumption -- and in one case at least, all indications point the other way. Whereas we recognize that there are some discrepancies in the assumption that retail trade employment follows population exactly, we believe that this is as far as our present knowledge can logically be expected to extend, and for the future prediction no adjustment was made.

There is one basic theme which we attempted to carry through this study; that is, to use as few arbitrary correction factors as possible. It would be possible to account for all discrepancies noted in the past trend analysis simply by applying correction factors to the theoretical values. However, while such a procedure would result in good checks for past trends, each factor would have to be evaluated to determine if it would remain constant for the period of future projection, or whether in reality the discrepancy is not simply the result of an isolated change such as the opening of a new shopping center. For this reason no factors were used to account for small localized differences unless there was a very definite trend, and one which appeared to be stable and long term.

Similarly, no attempt was made to "locate" new shopping areas as it was felt that realistically this was no more than a guess, and that the procedure used would result in a smaller error of estimate.

5. Distribution of Population

As a first approximation in developing a rational method of distributing population growth it was assumed that the new population would

distribute itself in accordance with highway accessibility to employment at the end of the study period and the residential "holding capacity" of the zone. In a manner similar to that used for manufacturing employment, predictions of the population growth were made for each town on the basis of accessibility and holding capacity only, and this theoretical value was then compared with the actual known growth. On the basis of this analysis considerable variation between the actual and theoretical values was noted.

In an attempt to determine the unknown factors causing this variance, the aid of the residential developers in the area was sought. Questionnaires were mailed to all developers in the area with a request to rate any or all of the towns with which they were familiar. An over-all rating from one to five was requested for each town and in addition, the questionnaires requested that unfavorable conditions be noted. These returns, together with the researchers' knowledge of the area, formed a basis for explaining the variations between actual and theoretical values.

For example, it was found that poor sewer and/or water facilities, or prohibitively costly installation, reduced the potential growth of a town by 50%. Unreasonable lot size, or house size controls, each resulted in a growth of only 75% of that which would have occurred under more reasonable conditions. Land shortage, or high land cost, reduced growth to 75% of that which might have occurred. Likewise, lack of large development tracts, that is, divided ownership, reduced growth by a factor of 0.75. In two towns it was noted that large land areas were being held for speculative purposes in the hope that prices would increase. This seemed to reduce growth to only 50% of that which would have normally occurred. On the plus side, the factors increasing growth appeared to be: (1) lax building codes, which triple growth; (2) picturesque homesites, which double growth; and (3) prestige, which may double or triple the rate of growth depending

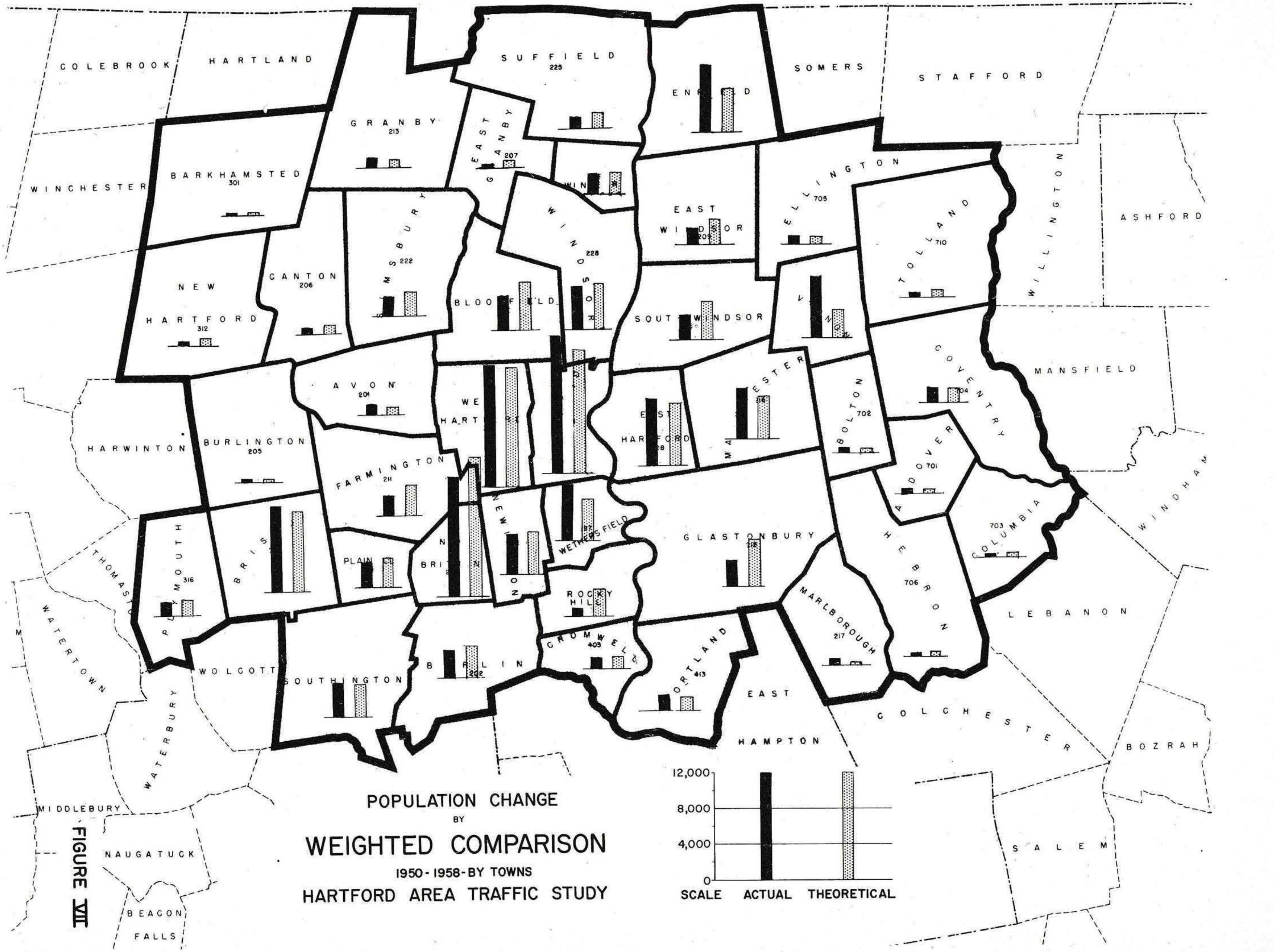
upon the strength of this factor.

By studying the area on a town-by-town basis and applying these weights, it was possible to account for most of the disparity between the actual and theoretical values to produce the comparison shown on Figure VII. This was the extent of our investigation as this provided a very close check. For projection into the future, these weights were investigated in an attempt to predict which could change, and more important, which were likely to change with time. Perhaps the most important of the changing weights is prestige. We have observed, over a period of time, that the prestige areas for residential development do change, generally moving toward the west as the suburban sprawl continues.

6. Distribution of Car Ownership

Although car ownership is not a land use category, it is nevertheless a measure of land use activity, and inasmuch as it is such an important part of the analysis, an extensive study of these changing patterns was made. Car ownership will increase for two reasons: (1) there will be more cars in the future due to an increase in population, and (2) even if there were no increase in population, the number of cars would increase due to a higher rate of car ownership.

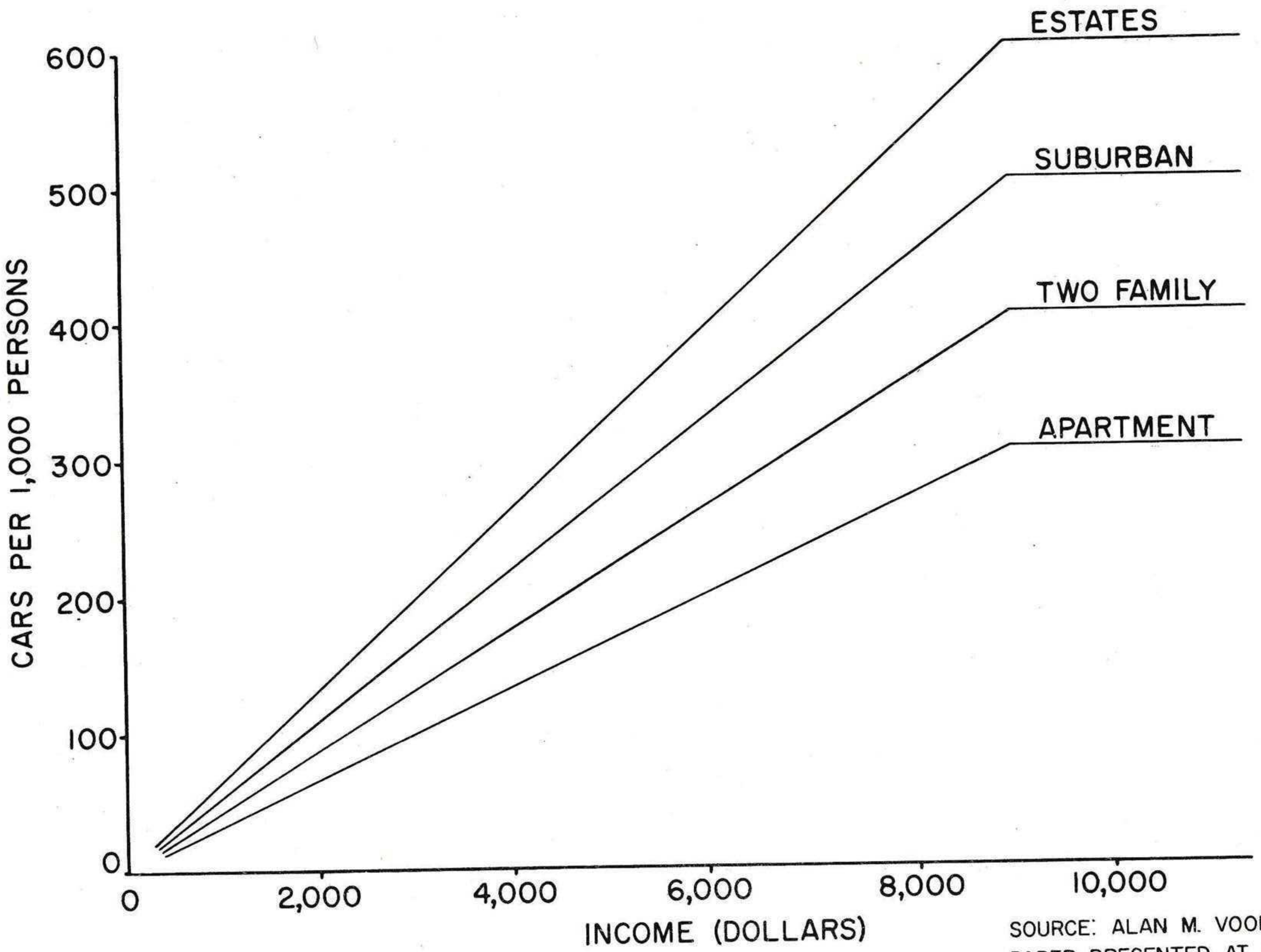
For the last 10 years or so, real income has been increasing at a somewhat constant rate of about 2 percent per year, nationally. This increase in buying power has enabled more families to own cars, and it has also resulted in more two car families. However, the car ownership rate is not expected to rise indefinitely; in fact investigations have shown that there appears to be a very definite ceiling on the rate of car ownership, above which it will not rise. This ceiling is different for various residential density classes. Figure VIII indicates the inter-relationship be-




POPULATION CHANGE
BY
WEIGHTED COMPARISON
1950-1958-BY TOWNS
HARTFORD AREA TRAFFIC STUDY

FIGURE VII

# CAR OWNERSHIP CEILING FOR DIFFERENT RESIDENTIAL DENSITY PATTERNS




SOURCE: ALAN M. VOORHEES, PAPER PRESENTED AT NICE, FRANCE, SEPTEMBER 1960.

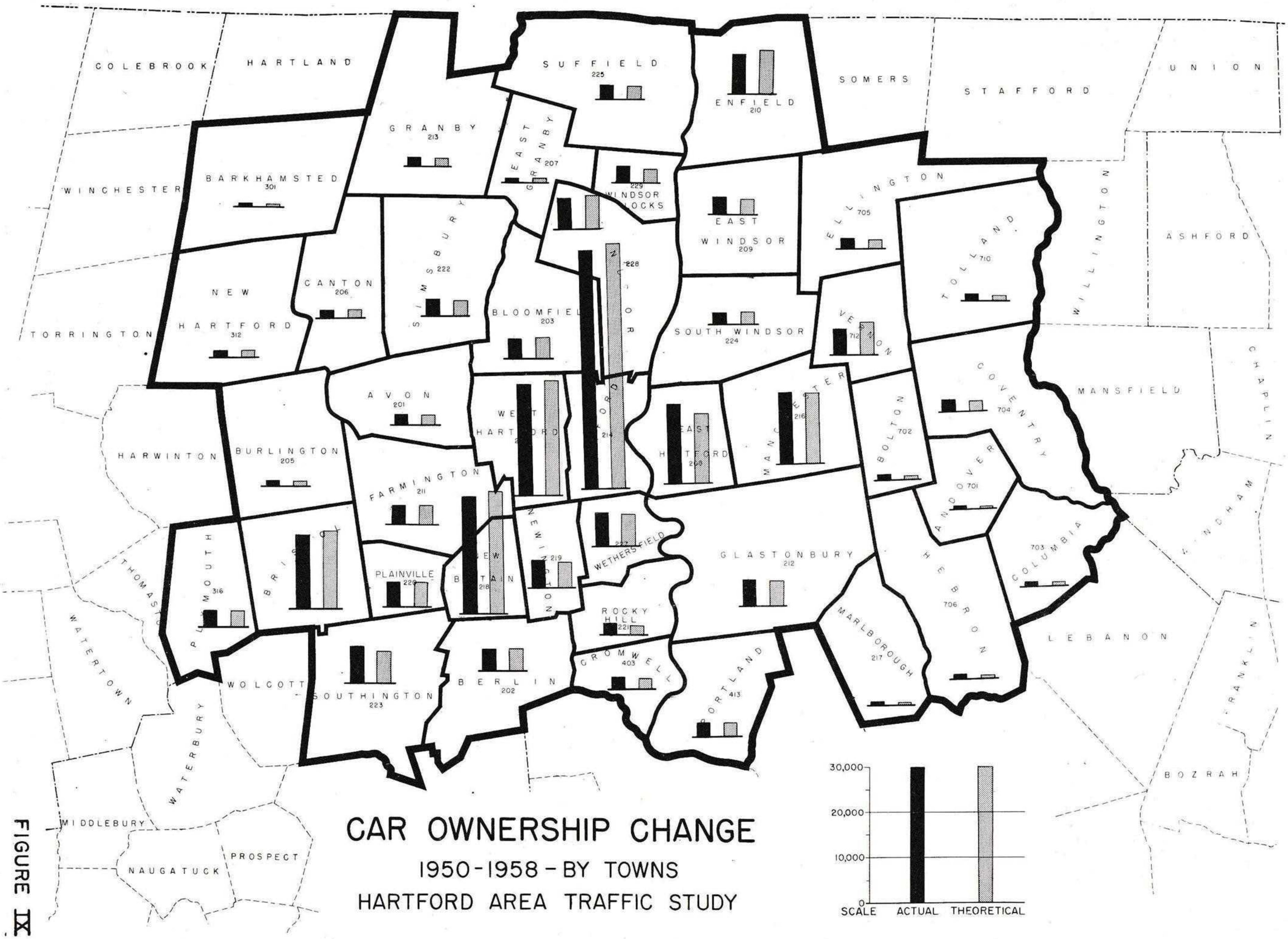
tween these factors for four densities of residential development. This chart shows that the rate of car ownership increases up to an income level of $8,000 to $10,000 per year, at which point it levels off at: 0.6 cars per person for estate areas, 0.5 for suburban areas, 0.4 for two family residential development, and as low as 0.3 cars per person for apartment house developments. These ceilings check very well with the actual rates now noted for the high income areas around Hartford and for the corresponding density classes. In accordance with these curves, we have assumed that the car ownership rate for the present population will increase at a rate of three percent per year up to the ceiling car ownership rate for the particular density class.

The increase in the number of cars due to increases in population was handled simply by adding the new population to the zone at the maximum car ownership rate for that particular zone.

These hypotheses on car ownership were checked by making a projection from 1950 to 1958 and comparing the projected estimates with the known growth. The theoretical and actual increases are plotted side by side on a map of the study area shown as Figure IX. This is without doubt the best correlation found for the entire study, and it was felt that this technique provided an exceptionally firm basis for future estimates.

7. Distribution Technique

Having developed the formulae for projecting the various pieces of the land use puzzle, it was then necessary to fit these pieces together in proper relationship, one to the other. Actually the method for doing this was recognized during the analysis of the individual parts when it was found that some of the categories of land use were more "alert" to the influences of future change than others. By treating each category in the order of its "alertness", a very logical chain reaction of development resulted.




# CAR OWNERSHIP CHANGE

1950-1958 - BY TOWNS

HARTFORD AREA TRAFFIC STUDY

FIGURE IX

It was found that manufacturing and service employment are the most alert to future changes which will affect their business interests. For this reason the increases in manufacturing and service employment were distributed first, and as should be recalled, the factors determining this distribution were related to the future year. For example, travel times reflected the assumed highway system for the target year.

After the new employment was "located" the new population was distributed in relationship to it The highway accessibility index reflected the relationship of employment and highways in the target year.

Finally, the increase in retail employment was distributed in accordance with the increase in population just determined. Car ownership was then calculated from the new distribution.

To summarize, the increase in employment was distributed first, it being assumed that this category was most alert to change. Second, since people live in relation to their places of employment, the increase in population was distributed in accordance to this relationship. Finally, the increase in retail employment, which follows population, was distributed.

It is becoming apparent to the researchers close to the field of traffic forecasting that in order to obtain realistic estimates of future traffic, the feedback effect of future changes in the highway network on the future land use distribution must be considered. To accomplish this it is necessary to build up the city in steps over time. For example, instead of projecting from 1960 as a base year directly to the design year, 25 years or so hence, it is necessary to consider intermediate points and make projections in perhaps five year intervals. The Hartford Area Traffic Study considered the years 1965, 1975, 1990 and the "horizon year", which in Hartford is about the year 2010. In this way the procedure was able to recognize the effect of the changes occurring throughout the period, such

as the radically expanding highway system which influences the future distribution of land use. Although the necessity of approaching the problem in this way has been realized, this is the first major traffic study to apply this approach.

C. Traffic Analysis

1. The Gravity Model

As described previously the Gravity Model derives its name from the fact that it closely resembles Newton's formula for the law of gravity. The resulting formula as used for traffic studies, distributes vehicle trips in proportion to the drawing power of an area which represents the mass, and inversely as some power of the distance between the areas.

It has been found from various studies made throughout the country which have used this technique, that to obtain sufficiently accurate results for traffic forecasting work, the basic differences in trip types must be recognized and that these types must be studied separately. The purpose of trips can be classified into innumerable categories, and the gravity model formula parameters adjusted to handle each. In actual practice it is found that at least four categories must be used.

2. Trip Purpose

The traffic model used in this study therefore is a four-purpose model; that is, separate distributions are made for each of the four trip purposes, these being work, social, commercial, and non-home-based. Separate land use information is required for each trip purpose, for both trip attraction and trip production for each zone, as described below.

a. Work Trips -- Work trip production is based on the labor force, which in turn is related to the population of the zone. For the distribution of work trips a measure of attraction for each zone must be developed. This measure can be any one of a number of factors: employment,

floor area, gross sales, etc. For this study total employment was used, inasmuch as employment data were readily available. The factors used for the distribution of work trips then are: labor force (which is derived from population) and total employment, each on a zone-by-zone basis.

b. Social Trips -- Social trips are defined as those trips made for the purpose of visiting friends. They are trips between residential zones and are therefore attracted by people. The trip production for social trips is based on car ownership which is directly related to population. Hence, the information required from the land use analysis for the distribution of social trips is population and car ownership.

c. Commercial Trips -- Commercial trips are those made between the home and an area of commercial land use. The attraction factor for commercial trips must be some measure of the intensity of the commercial activity of the zone. Retail trade employment was used for this measure. As with social trips, the trip production factor for commercial trips is car ownership; therefore the only new information required of the land use analysis for the distribution of commercial trips is retail trade employment.

d. Non-Home-Based Trips -- Non-home-based trips are defined as trips which have neither origin nor destination at the home. They are composed of housewives shopping from store to store and salesmen and doctors traveling between calls, as examples. It is seen that some of these trips are related to commercial areas as with the housewife and, in part, the salesman. However, some salesmen's trips are to industrial areas and some are to residential areas. To account for the diverse trip types an index including population, total employment, and retail employment was developed for their distribution. It should be noted that no new information is required for this distribution. In summary, the information to be derived from

the land use analysis is the location of: (1) Labor Force, (2) Total Employment, (3) Car Ownership, (4) Retail Trade Employment, and (5) Population.

Figure X shows a plot of the travel time factors which were used; one curve for each of the four trip purposes. From these curves you can see that the average trip length varies by trip purpose, and even that the trip length distribution is different. Although these curves do not necessarily represent trip length distribution, they do give an indication. For example, the shortest trip type is the non-home based trips, with commercial trips a close second. The longest trips are work and social trips, but even these are rarely as long as 60 minutes, with the vast majority less than 30 minutes. Note also the steepness of the curves for all trip types, accentuating the low values of travel time. This indicates the tendency for very short trips, and the attempt on the part of the motorist to minimize travel time. These curves do not consider terminal time at either end of the trip, although there is some indication that they could be made more flexible by adding terminal time.

3. Gravity Model Computations

Example 1, following, is a sample computation for the Gravity Model. This example is made up of two parts. The first illustrates how traffic from a residential area will distribute itself to the three shopping areas on the basis of the local street travel times. The second tabulation illustrates how the distribution is changed by the construction of an expressway connecting the residential area to one of the shopping areas. It is intuitively evident that expressways do change travel patterns and the fact that the Gravity Model can recognize and predict this change sets it apart from the other, more commonly used, methods of analysis. This is one of the primary differences between the Gravity Model and the Fratar or Multiple Regression methods.

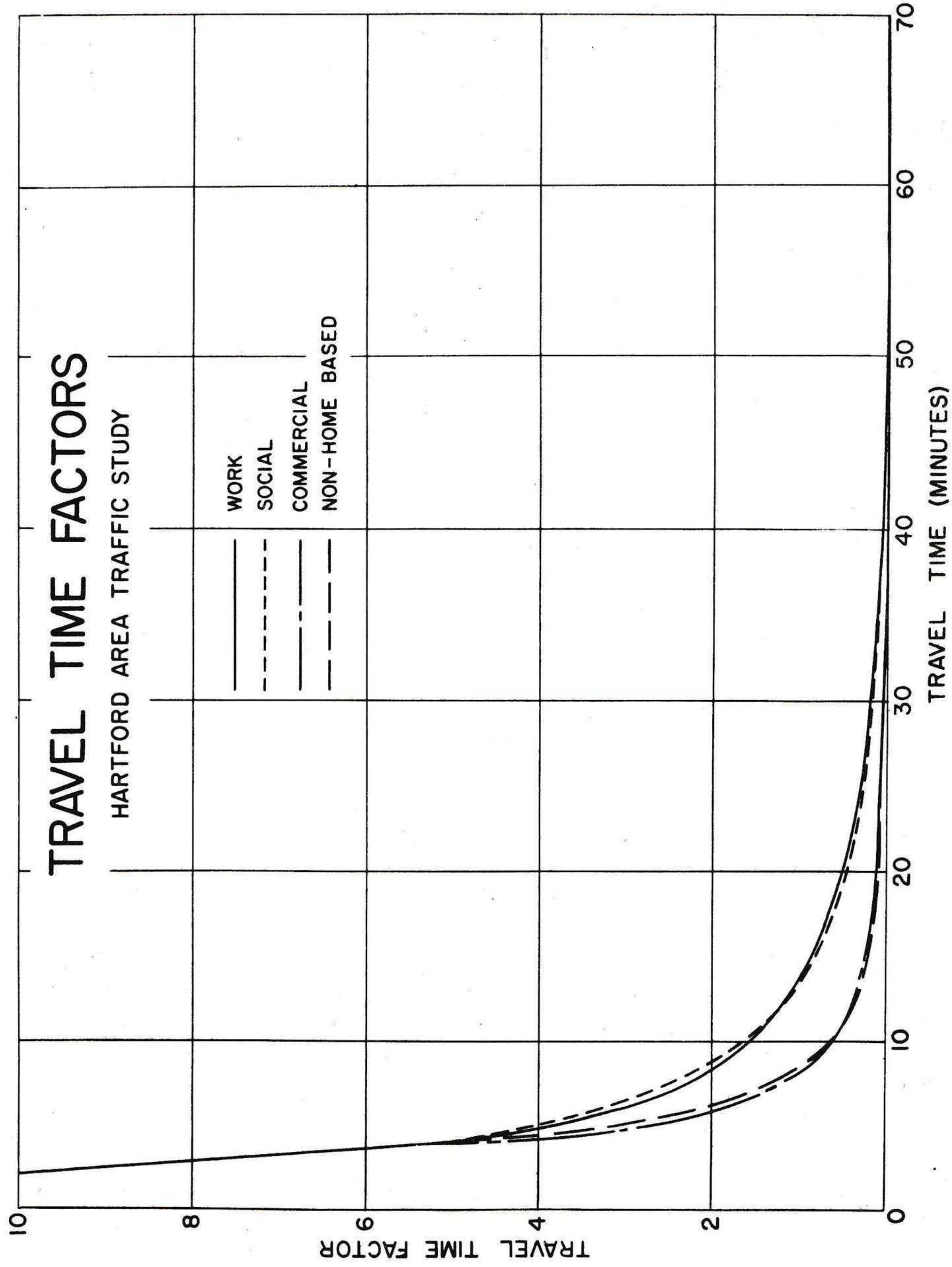
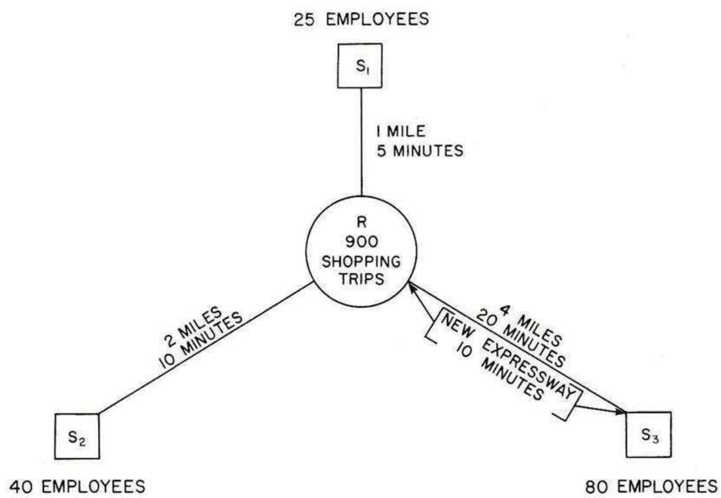

TRAVEL TIME FACTORS
HARTFORD AREA TRAFFIC STUDY
WORK
SOCIAL
COMMERCIAL
NON-HOME BASED
TRAVEL TIME FACTOR
TRAVEL TIME (MINUTES)
0
2
4
6
8
10
10
20
30
40
50
60
70

FIGURE X

## EXAMPLE NO. 1
## HYPOTHETICAL APPLICATION OF THE GRAVITY MODEL




| EXISTING "PULL" | PERCENT OF TOTAL "PULL" | NUMBER OF TRIPS |
|---|---|---|
| $S_1 = \frac{25}{(5)^2} = 1.0$ | 62.5 | 563 |
| $S_2 = \frac{40}{(10)^2} = 0.4$ | 25.0 | 225 |
| $S_3 = \frac{80}{(20)^2} = 0.2$ | 12.5 | 112 |
| TOTAL "PULL" = 1.6 | 100.0 | 900 |

| "PULL" AFTER EXPRESSWAY IS BUILT | PERCENT OF TOTAL "PULL" | NUMBER OF TRIPS |
|---|---|---|
| $S_1 = \frac{25}{(5)^2} = 1.0$ | 45.4 | 408 |
| $S_2 = \frac{40}{(10)^2} = 0.4$ | 18.2 | 164 |
| $S_3 = \frac{80}{(10)^2} = 0.8$ | 36.4 | 328 |
| TOTAL "PULL" = 2.2 | 100.0 | 900 |

INCREASE IN TRIPS TO $S_3 = \frac{328}{112} = 2.92$

4. Travel Time Factors

For this example it was assumed that the exponent of travel time was "2". Actually, studies have shown that this exponent is not necessarily "2" but that it varies with trip purpose, and furthermore, that it is not necessarily a constant exponent for any particular trip purpose. For this reason, instead of using an exponent, most traffic studies use travel time factors which are developed by comparing the actual and theoretical trip distributions.

The travel time factor can be defined as a measure of the resistance of motorists to travel time. For example, if travel time were of no significance, there would be just as much likelihood of a resident of Hartford working in Boston as in Hartford, and the travel time factor would then be "one" for all trips. Realistically, we know that people attempt to minimize travel time by living near their jobs and shopping near home. What we need to know is the distribution of travel times between places of residence of persons and their places of employment and shopping.

Travel time factors can be developed in several ways. The traditional method and perhaps the most straight-forward way of developing travel time factors is to conduct a small home interview survey designed for this purpose. This was one method used for checking the Hartford Area Traffic Study. Actually, it has been found that travel time factors are so nearly similar nationwide that very little error would be introduced by the use of standard curves. This suggests another way of checking -- using standard curves to make the Gravity Model computations and then checking the trip length distribution thus obtained against known values from, for example, a roadside interview origin-destination survey. By grouping inter-zonal movements by travel times and comparing the volumes produced by the model with those shown by the roadside survey, a ratio of actual to theoretical values

can be developed. A plot of this ratio versus the travel time will readily show any significant bias.

Example 2, following, is a sample computation used in the development of these travel times and of the Gravity Model formula itself. Consider a residential area located among four employment areas. For ease of computation, assume that each of these employment areas is the same size and has 400 employees each. Assume, for the moment, that travel time has no bearing on the relationship of where people live and work. Under this assumption it would be just as likely that a resident of New Haven would work in Hartford as in New Haven, and everything else being equal the 300 work trips originating from the residential area would be distributed equally among the four employment areas. Prorating the trips on this basis produces a distribution of 75 trips to each of the four employment areas.

In reality it is known that travel time does have an effect on trip distribution. From some type of survey, probably a home interview survey the actual distribution of trips can be determined as shown. By taking the ratio of the actual trips to the prorated trips a factor is obtained which, when plotted against the travel time from the residential areas, results in a curve with the equation $R = kd^x$. With further analysis of this data it is possible to develop the equation of the Gravity Model as shown. Define the terms as follows:

Total Trips from Zone 1 = $T_1 = T_{1-1} + T_{1-2} + \dots T_{1-n}$

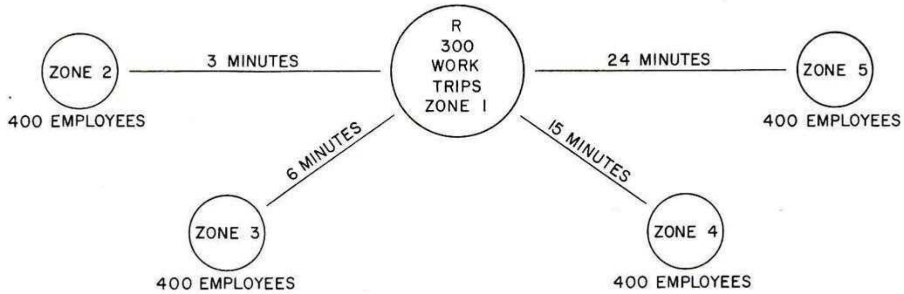
Actual Trips from Zone 1 to Zone n = $T_{1-n}$

Prorated Trips from Zone 1 to Zone 2 = $T_{p(1-2)} = T_1 \times \frac{E_2}{E_t}$

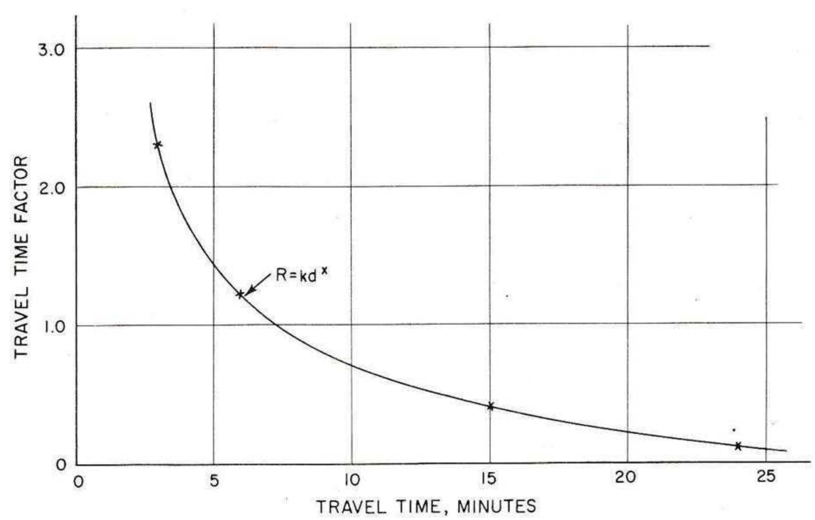
Then: $\dfrac{T_{1-2}}{T_{p(1-2)}} = kd^{x}_{1-2}$ and: $T_{1-2} = kd^{x}_{1-2} \times \dfrac{E_2}{E_t} \times T_1$

# EXAMPLE NO. 2

## METHOD OF DEVELOPING TRAVEL TIME FACTORS




| ZONE | PRORATED TRIPS | ACTUAL TRIPS | TRAVEL TIME FACTOR, RATIO A/P | TRAVEL TIME |
|---|---|---|---|---|
| 1-1 | 0 | 0 | -- | -- |
| 1-2 | 75 | 173 | 2.3 | 3 |
| 1-3 | 75 | 90 | 1.2 | 6 |
| 1-4 | 75 | 30 | 0.4 | 15 |
| 1-5 | 75 | 7 | 0.1 | 24 |



or in terms of a general equation, where i and j are any two zones:

$$T_{ij} = T_i \times kd_{i-j}^{x} \times \frac{\text{Attraction}_j}{\text{Sum of all Attractions}}$$

In order to develop a workable model with the accuracy required for traffic estimation work, it is necessary to make separate distributions for the various major classes of trip purpose. As mentioned previously, HATS used a four-purpose model. The three principal factors required for the generalized equation for each of the four trip purposes are given in Table 2 below:

TABLE 2

| Trip Purpose | Factor Relating to | | |
|---|---|---|---|
| | Trip Attraction | Trip Production | Exponent |
| Work | Total Employment | Labor Force | 0.9 - 1.2 |
| Social | Population | Car Ownership | 1.2 - 1.4 |
| Commercial | Retail Employment | Car Ownership | 2.0 - 3.0 |
| Non-home Based | Population<br>Total Employment<br>Retail Employment | Population<br>Total Employment<br>Retail Employment | 2.5 - 3.0 |

D. Checks for 1960 Model Calibration

1. Source Data

The Gravity Model approach has been used in many cities of varying size, and from these previous studies it has been possible to develop the basic constants for the Gravity Model equation. Also, it has been shown that the constants used are similar nationwide, or vary in a predictable manner by city size. Some of the information used for the model, such as the trip production rates, is data which is required for any comprehensive traffic study and therefore has been researched in great detail. Some information, on the other hand, has been developed specifically for the HATS Gravity Model. Generally, there are three main factors which must be checked in order to calibrate the model: (1) trip production

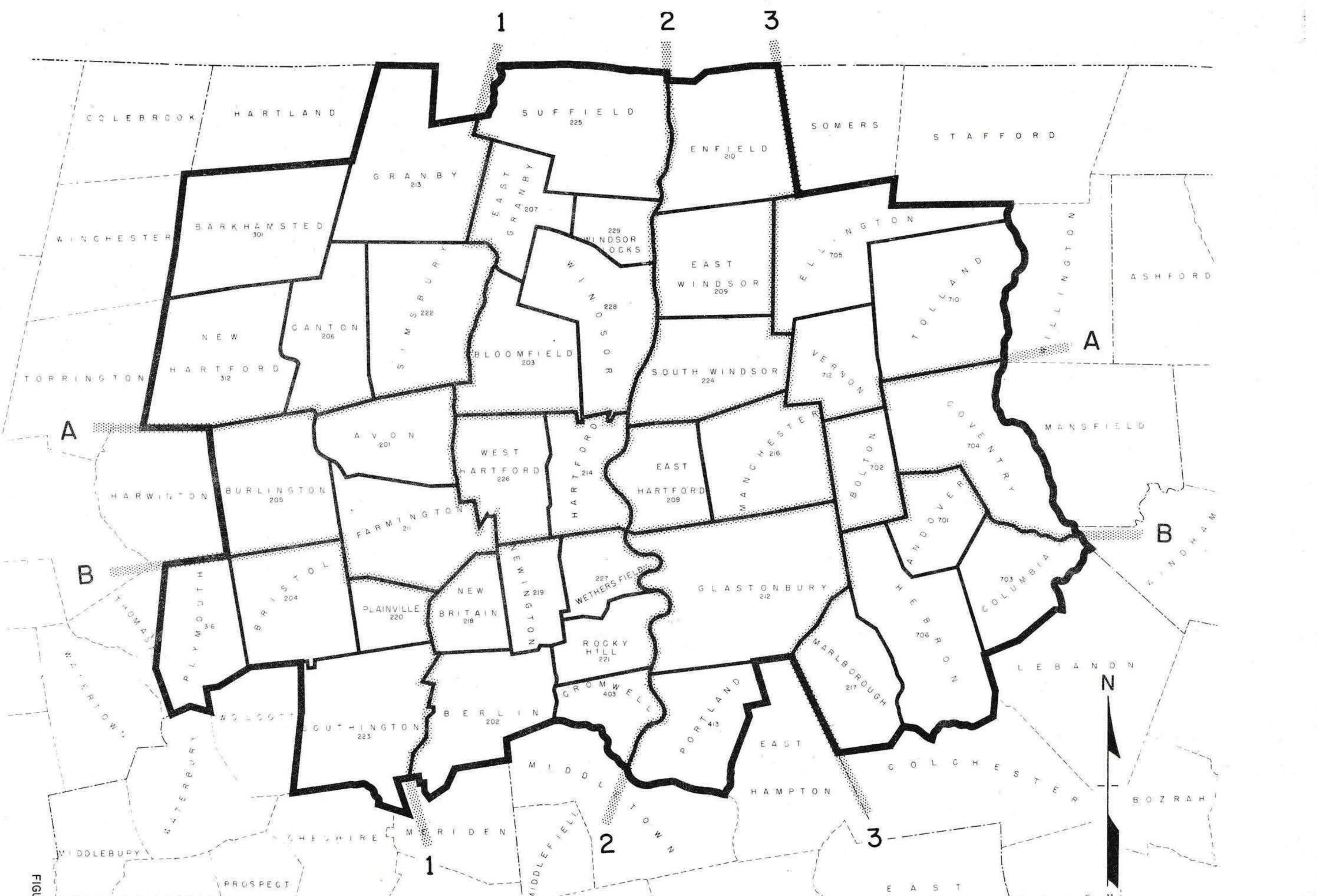
rate, (2) trip length, and (3) trip distribution. To insure that the model was completely reliable and could simulate the flow of traffic accurately, all three of these factors were checked in at least two ways as discussed below.

2. Screen Line Checks

One of the more commonly used methods of checking study techniques is the screen line check. This method compares the total actual travel across a set of screen lines to the predicted travel across the same lines. If the predicted volumes across the screen lines are not significantly different from the actual volumes, indicating that in these areas the model is accurate, the same accuracy is assumed to hold for the areas adjacent to the screen lines.

Screen lines are chosen to effectively isolate areas and to divide areas so that the total inter-area travel may be checked. They usually conform to natural physical boundaries or cross defined corridors of travel. When significant differences are found between actual and predicted traffic volumes, the amount or trend of the difference often indicates the source of error. For instance, if all of the predicted volumes across several or all the screen lines are uniformly larger than, or smaller than, the actual traffic, then the error would probably lie in the rate of trip production. Errors in only one or two screen lines might be traced to localized problems or to a particular trip purpose.

The screen lines used for HATS are shown on Figure XI and the final screen line checks for the 1960 Model are reported below in Table 3. The "actual" traffic values for these checks are based on field counts of all streets crossing the screen lines, taken in September and October, 1960. The theoretical values are based upon the "group to group" totals (from Model Computer Run Number 5A) with the following trip production rates: 1.13, 0.80,




SCREEN LINE LOCATIONS
HARTFORD AREA TRAFFIC STUDY

FIGURE XI

1.00, 1.00, and 0.50 for work, social, commercial, non-home-based-passenger and non-home-based-commercial trips respectively.

Prior to the study it was arbitrarily determined that the limits of accuracy for the screen lines would be plus or minus 10 percent. It is seen that all screen line ratios are well within this limit.

TABLE 3

HARTFORD AREA TRAFFIC STUDY
SCREEN LINE CHECKS
(Group to Group, Run 5A)

| Screen Line | Theoretical Local | Theoretical Through | Theoretical Total | Actual | Ratio: Actual / Theoretical |
|---|---|---|---|---|---|
| 1 | 84,500 | 3,200 | 87,700 | 90,000 | 1.03 |
| 2 | 158,200 | 12,000 | 170,200 | 154,500 | 0.91 |
| 3 | 68,100 | 9,100 | 77,200 | 73,000 | 0.95 |
| A | 159,000 | 11,600 | 170,600 | 164,200 | 0.95 |
| B | 176,700 | 12,300 | 189,000 | 190,900 | 1.01 |

3. Home Interviews

Although the screen lines show extremely favorable checks, it is conceivable that two or more factors might be in error and the cumulative error would cancel out. As an example of this, it is possible for the trip production rate to be too high but the trip length distribution too low, producing a net effect on the screen lines of zero. Although trip production factors have been researched in detail for various studies, and it has been shown that these factors can be predicted closely from city size, in order to be absolutely certain that these were correct a home interview survey was made during the summer of 1960.

The survey was limited to the collection of data on the trip production rates for passenger vehicles and could therefore be based on a very small sample. On the basis of statistical methods it was determined

that a sample of about 200 families, chosen randomly from throughout the area would provide sufficiently accurate results for total auto trip production. The families to be interviewed were taken from phone books, and to insure randomness of the sample, random numbers were used to choose those to be interviewed.

The results of this survey show that the sample was statistically sound for the determination of the average number of trips per day per car to a correctness of 95 percent, with a variation of plus or minus 10 percent. A lower degree of accuracy was of course, obtained for trip production by purpose. The results of this survey and the trip production rates are recorded in Table 4 below.

TABLE 4

HOME INTERVIEW RESULTS

| Trip Purpose | Total Trips Recorded | Trips per Car |
|---|---|---|
| Work | 283 | 1.33 |
| Social | 175 | 0.82 |
| Commercial | 203 | 0.96 |
| Non-home Based | 202 | 0.95 |
| Totals | 863 | 4.06 |

Table 4 shows that there are 1.33 work trips per car per day. Of these, 1.14 trips are from home to work, while 0.19 are of the "serve passenger" variety. This latter group would include the wife who takes her husband to the bus stop and returns home while he continues to work on the bus, or the driver stopping to pick up a pool rider who works either in the same place as the driver or near to it. These "serve passenger" trips have been deducted from the work trip production total and since they have the characteristics of non-home-based trips should be contained in the non-home-

based trips. However, to insure a conservative appraisal of future traffic these trips were completely ignored.

Since the home interview survey was designed to determine trip production for vehicles only, it was necessary to increase the total trip production to account for commercial traffic. This traffic includes those trips produced by buses, taxis, small delivery trucks, etc., trips which are generally rather short in nature, fitting into the non-home-based category. Generally, throughout the study area, it is found that on a vehicle mile basis these trips account for between 8 and 12 percent of the total traffic. However, due to the short trip length, when converting these from a percentage on the basis of vehicle miles to percentage of trip production, it is found that they represent between 13 and 20 percent of the total trips produced. Choosing the smaller of these values, the 13 percent, results in a trip production rate for commercial non-home-based trips of about 0.50 trips per car per day.

Rounding off and summarizing, the values used for the Hartford Area Traffic Study are shown in Table 5 below.

TABLE 5

TRIP PRODUCTION

| Trip Type | Trips per Car per Day |
|---|---|
| Work | 1.1 |
| Social | 0.8 |
| Commercial | 1.0 |
| Non-home Based | 1.5 |
| Total | 4.4 |

4. River Crossing Trip Length Distribution Check

The Connecticut Highway Department was truly fortunate in having complete and recent data available from the 1956 Coverdale and Colpitts Connecticut River Survey which could be used for checking purposes. This data formed a bench mark for several important checks on the Gravity Model, the trip length distribution being one of these. Shown below in Table 6 and as a graphic portrayal in Figure XII is one method of checking trip length distribution across a screen line. To accomplish this check, the origin and destination movements produced by the 1960 Gravity Model were compared with similar movements as measured by the 1956 origin-destination survey. These comparison movements were then grouped into 10 minute intervals of travel time and the percentage of trips in each interval computed for comparison. This comparison should be very stable due to the large number of trips involved, actually over 80,000, which is more than half the total of the 1960 average daily traffic. From these data it is evident that the model is producing slightly too few long trips, and conversely too many short trips, resulting in an over-all low estimate of traffic.

TABLE 6

COMPARISON OF TRIP LENGTH DISTRIBUTION

River Crossing Check

| Trip Length Minutes | % Actual Volume | % Theoretical Volume |
|---|---|---|
| 0 - 9 | 3.3 | 3.8 |
| 10 - 19 | 37.6 | 38.8 |
| 20 - 29 | 27.1 | 31.2 |
| 30 - 39 | 10.5 | 13.9 |
| 40 - 49 | 10.7 | 9.2 |
| 50 - 59 | 8.0 | 2.3 |
| 60 - Over | 2.8 | 0.8 |

Average Trip Length: Actual 8.2

Theoretical 7.4

# HARTFORD AREA TRAFFIC STUDY

## RIVER CROSSING CHECK

## COMPARISON OF TRIP LENGTH

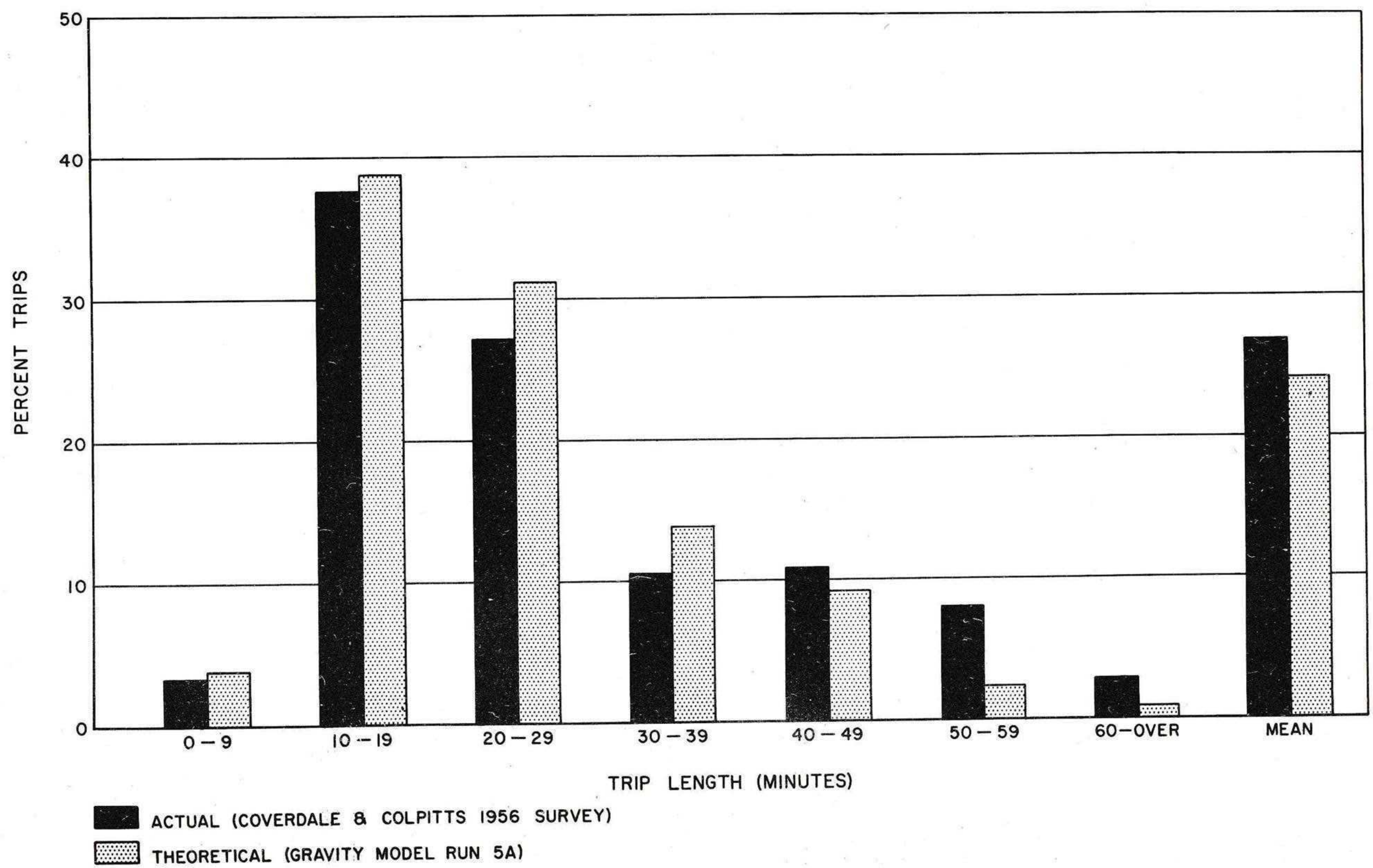



FIGURE XII

5. Commutation Check

Connecticut has a wealth of information, from the Department of Labor and the Connecticut Development Commission, not usually available in other states. Among other purposes, this was used for checking the Gravity Model's distribution of work trips. The information is reported on a town-by-town basis, showing the residences of workers at manufacturing establishments employing 100 or more workers. As a check, the actual zone to zone movements, as shown by the commutation patterns developed by the Connecticut Development Commission, were compared with the theoretical values computed on the basis of the Gravity Model. These lengthy tables are not included in this report.

6. Summary of Model Calibration and Checks

The main sources of information for checking and calibrating the Gravity Model were: home interview origin destination survey, roadside interview origin-destination surveys, field counts of screen line volumes, and commutation patterns developed by the Connecticut Development Commission. These have been effectively applied to adjust the Model for local conditions which do not conform to the norm. The adjustments made have produced an accurate Model which, within satisfactory limits, is able to simulate the actual flow of traffic for the base year. All available information and known methods for checking the Model have been applied, and in all instances the checks between the actual field data and the theoretical information developed from the Model are comparable within the limits of accuracy required for a study of this type.

E. Tree Building and Network Assignment

No section of the report with this title would have been possible prior to 1958 because assignment methods for computer analysis had not then been developed. Any assignment analysis which was made before that

time was accomplished manually on a route by route basis. However, in 1957 and 1958 much work was done on computer analysis of traffic data and ultimately a computer program was developed which could determine the shortest path through a highway network. This is called the tree building program and is one of the most valuable recent developments in the field of traffic estimation.

1. Tree Building

Although the Moore Minimum Path Algorithm which HATS used for the tree building process is amazingly simple in principle, it required years of research by numerous organizations for its development. (1) (2)

Basically, a tree is made up of the shortest time paths to reach any zone centroid in the system from the home centroid, or starting point. With all street and highway segments between intersections coded with respect to distance and assumed speed entered into the computer memory, the computer is then able to determine the shortest travel time paths between any two points in the system.

Starting from any particular centroid (the home node,) the computer searches for the link radiating from that node which has the lowest travel time. When it is found, the travel time and node number are recorded in the computer memory together with the "back node", the node from which the link originated, in this case the home node. The next step is to search for the second shortest link radiating from the home node and the same information is recorded. This process is repeated until all links radiating from the home node have been processed.

---

(1) William L. Mertz, unpublished paper presented to Origin and Destination Surveys, 40th Annual Meeting, Highway Research Board.

(2) All computer programs, including the tree building, assignment, Gravity Model and Land Use Model used for HATS, were written by the Computer Programming Unit of the Connecticut Highway Department. The Computer Programming Unit as well as the Division of Planning wish to thank Mr. William Mertz, then of the B.P.R. Division of Development, Office of Operations, for his help during the development phase of the tree building and assignment programs.

The instructions then tell the computer to process the node closest to the home node, performing the same operations as on the home node, always adding the travel time to reach succeeding nodes onto that already obtained to reach the node being processed. When one node is processed, the computer always goes to the node next furthest away from the home node, working out in concentric circles away from the home node.

During the tree building process, a route will occasionally be found which is shorter than one already recorded. This situation is handled simply by comparing the travel time just obtained with the one already recorded. If the new time is greater, the new route is discarded; if the new time is less, the old route is erased from the computer memory and the new one recorded.

The final product, the tree, is a computer tabulation composed of the shortest travel time from the home node to each other node as well as the path or route which must be followed to make the trip in this minimum time. A separate tree is required for each centroid, and for HATS this is 119 trees. Figure XIII is an example of a tree for one such centroid.

2. <u>Assignment</u>

Since the shortest time path has been recorded during the tree building process, the interzonal volumes obtained from the traffic and land use models can quite simply be placed on these trees. The sum of all link volumes then represents the traffic expected on the various links for the particular origin-destination pattern.

In practice, this is accomplished by entering the volume between a particular origin and destination into the computer, together with the trip trace for this trip and then tracing the trip through the tree, adding the particular volume to each link. Each successive origin-destination volume is added to the preceding volume already on the link untill all volumes have been processed.

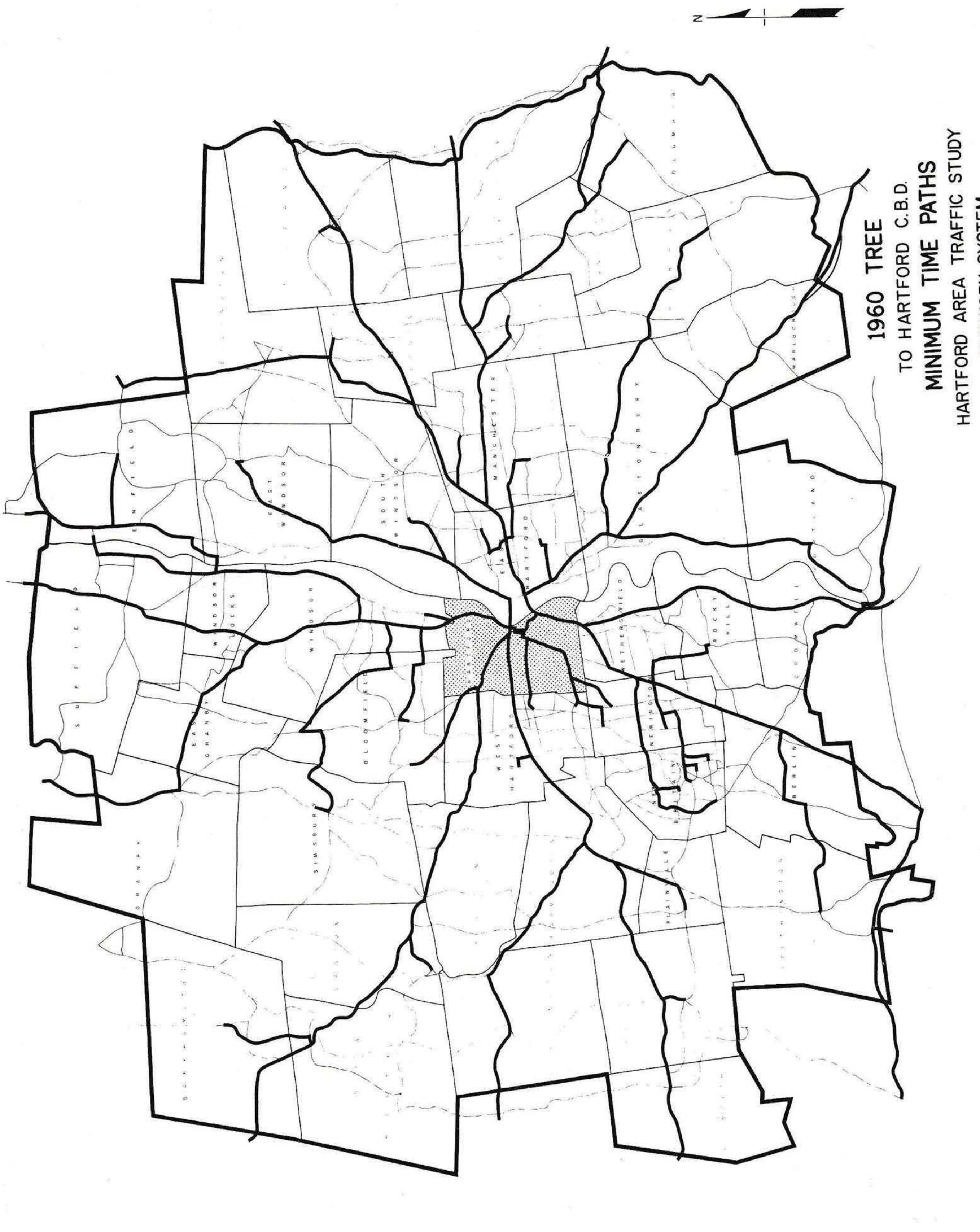
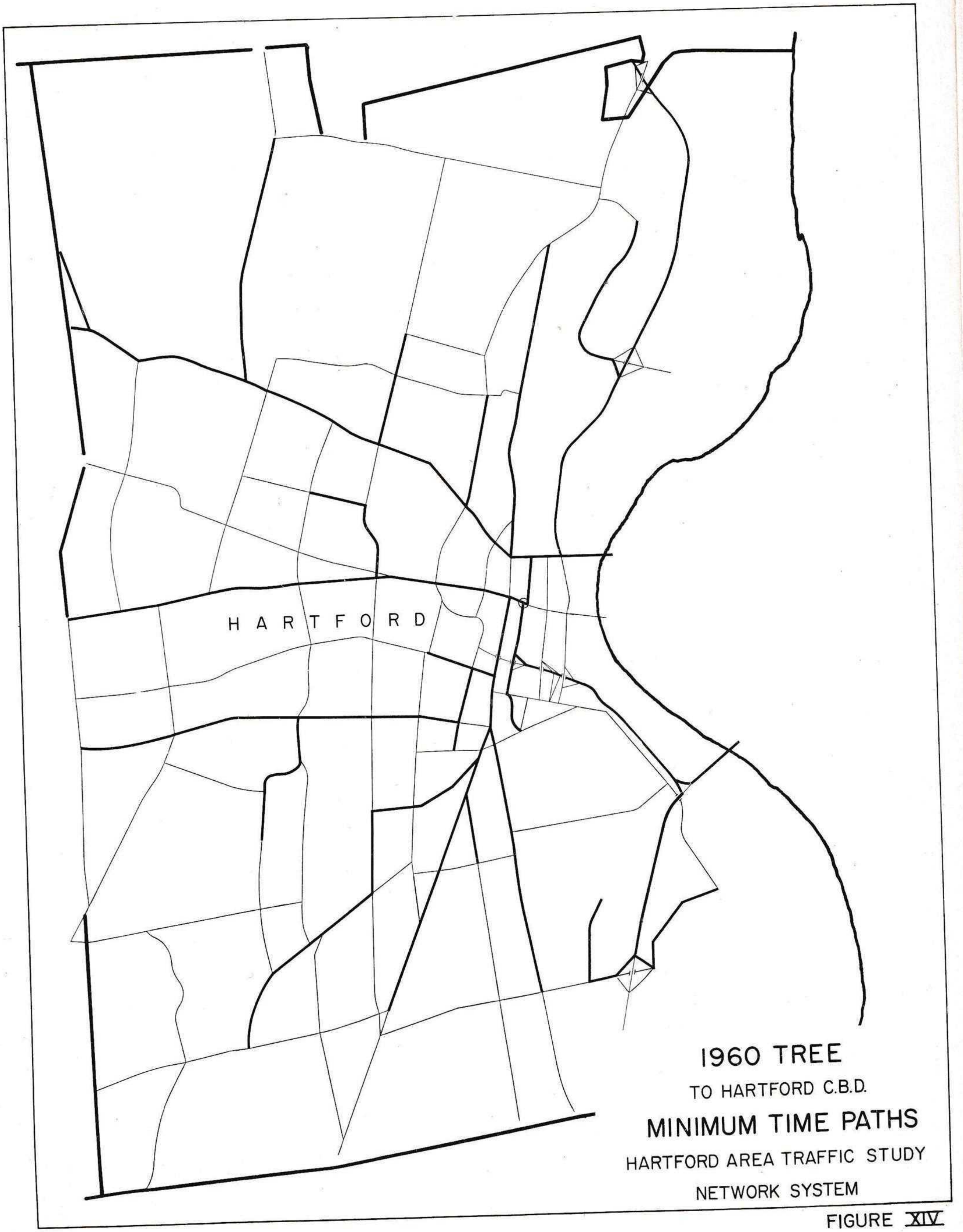

1960 TREE
TO HARTFORD C.B.D.
MINIMUM TIME PATHS
HARTFORD AREA TRAFFIC STUDY
NETWORK SYSTEM
ENFIELD
SUFFIELD
EAST WINDSOR
SOUTH WINDSOR
MANCHESTER
EAST HARTFORD
GLASTONBURY
WINDSOR LOCKS
WINDSOR
EAST GRANBY
BLOOMFIELD
WEST HARTFORD
WETHERSFIELD
ROCKY HILL
NEWINGTON
BERLIN
SIMSBURY
PLAINVILLE
GRANBY

FIGURE XIII




1960 TREE

TO HARTFORD C.B.D.

MINIMUM TIME PATHS

HARTFORD AREA TRAFFIC STUDY

NETWORK SYSTEM

FIGURE XIV

3. Alternate Assignment Methods

The assignment procedure just described is the simplest of several which are available for computer analysis, and is termed the "All or Nothing" assignment. "All" the volume is assigned to the route with the shortest travel time, "nothing" to any of the literally thousands of alternate routes.

a. Diversion Curve Method

In practice it is found that all motorists will not use the shortest travel time route between origin and destination. Some will follow the shortest distance route, while the majority will make some compromise between these two extremes. Many curves have been developed which attempt to approximate the actions of motorists in their choice of route. Most are based on a simple time ratio, comparing the ratio of the fastest expressway route with the fastest local street route.

For computer analysis, the problem comes in attempting to determine a realistic alternate route. The Washington study has approached the problem by doubling all expressway travel times and then building a new set of trees. In this way alternate routes and a travel time ratio are obtained. However, no data is available to support the assumption that the expressway travel times should be doubled -- perhaps multiplying them by 1.5 would produce better results. Different alternate routings would certainly be obtained.

b. Capacity Restraint Method

One difficulty encountered in computer assignment is that the raw answers obtained from the computer frequently show many local streets and some interchanges tremendously overloaded while others have little or no traffic. This results from the assumption that the entire

volume from a particular zone originates at a single street intersection rather than uniformly over the entire zone. This is a necessary assumption in order to keep the analysis within reasonable economic limits.

A second cause of difficulty results from the fact that some new expressways will have a much higher demand than capacity. An example of such a situation is I. 84 through Hartford and West Hartford. Analyses to date have shown that the demand on sections of I. 84 is approximately twice the planned capacity. This situation has been recognized for years, and has been confirmed by HATS.

Several approaches have been attempted in order to correct for these difficulties, all of which use the same basic principle. As volumes on segments of the network increase, the assumed speed is decreased. This principle is basically realistic and is compatible with known facts on volume-capacity-speed relationships. However, the methods of speed reduction vary widely.

For the Chicago Area Transportation Study, the only large scale study to use capacity restraint to date, volumes were assigned from randomly selected zones and street times were adjusted after each zonal assignment in a predetermined manner.

The Traffic Research Corporation Ltd. is working on a method whereby all traffic is assigned and then all street speeds adjusted in accordance with the volume-speed relationship which they have found to exist from extensive research. The entire volume is then re-assigned and the speeds adjusted again. This is an iterative process and their work to date has shown that with about four iterations the change for successive corrections is negligible.

A third possibility is that of assigning percentages of the total origin-destination table and adjusting speeds after each partial

assignment. These percentages might be 50-25-15-10 for successive assignments. This process is similar to the method previously described but elimentes the iterative nature and therefore guarantees closure after a predetermined number of assignments.

Finally, a fourth method proposes to recognize the basic nature of trips on the basis of trip length, recognizing: (1) that long trips, in the neighborhood of 20 to 30 miles, have alternate expressway routes which are very nearly comparable in terms of travel time, (2) that short trips should not be on the expressway at all, and (3) that the medium length trips, from 5 to 10 or 15 miles in length, should be the ones with first choice on the expressways. This approach would assign the origin-destination movements on the basis of three trip lengths -- medium first, long second, and short last, and adjust street speeds after each portion of the assignment. This perhaps, is the most realistic of the four methods described.

Although these methods would result in an improved assignment, it is noted that all of the methods described require several assignment and tree building processes. The tree building and assignment process is by far the most expensive part of studies such as this. For HATS it is safe to say that over 75% of the study cost is represented in tree building and assignment computer expense. The use of the methods described could easily double or triple the total cost of the study. Furthermore, research conducted by the Washington study concluded that for metropolitan areas the added expense of the diversion curve assignment was not warranted by the resulting slight improvement of the assignment picture.

Therefore, HATS used the all or nothing assignment principle and to correct for its shortcomings has adjusted the resulting volumes

manually. A manual capacity restraint feature was employed however, by reducing the speeds on I. 84 through Hartford. This was found to be necessary after a trial assignment placed approximately 180,000 ADT on this facility.

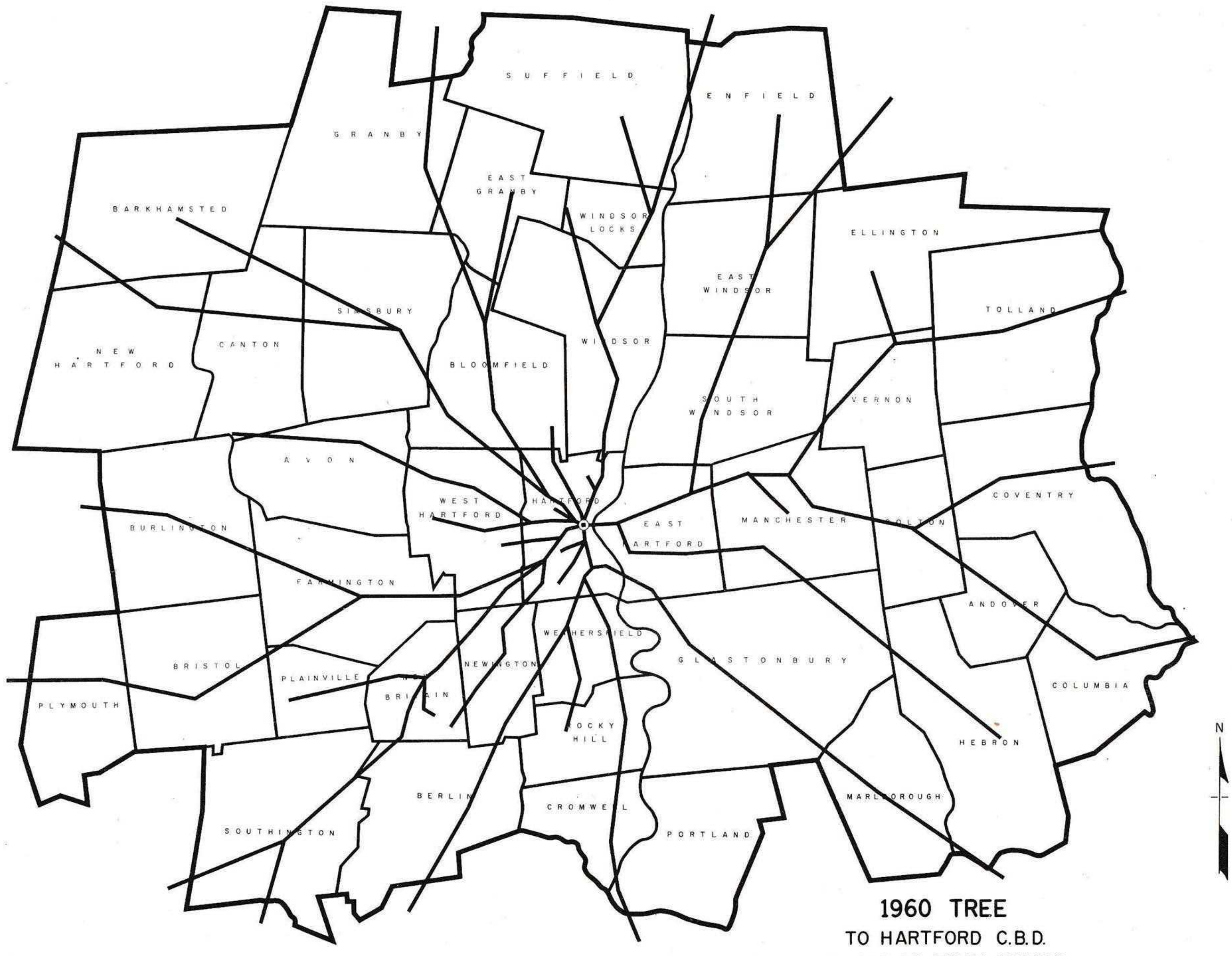
4. Desire Line Assignment

For many portions of an analysis such as this it is more convenient to work with a Desire Line Assignment rather than the entire network. The computer processes involved in tree building and assignment are exactly the same regardless of whether a desire line or the entire network is being analyzed. Only the input data changes. For the desire line assignment it is necessary to code a separate system with the straight line distance between centroids being analogous to the street segments in the highway network. The trees are built and the assignment is made on the basis of the shortest path, relative to distance. An example of a desire line tree is shown in Figure XV.

F. Summary of the Projection Process

The procedure used for this study, unlike previous methods, is lengthy at best for even the analysis of a single year. For the analysis of several years, working through the entire projection process from beginning to end for each projection period would result in a time-consuming, expensive operation unless a systematic, efficient flow of data from one process to the next were obtained. One advantage of the system developed for HATS is the complete inter-relationship between the land use and the traffic analyses. A diagram representing the flow of data through the process is shown as Figure XVI.

This diagram shows the continuous, orderly flow of land use and travel-time information toward the Gravity Model where the inter-zonal




## 1960 TREE
TO HARTFORD C.B.D.
**MINIMUM TIME PATHS**
HARTFORD AREA TRAFFIC STUDY
DESIRE LINE SYSTEM

FIGURE XV

# FLOW DIAGRAM FOR HARTFORD AREA TRAFFIC STUDY

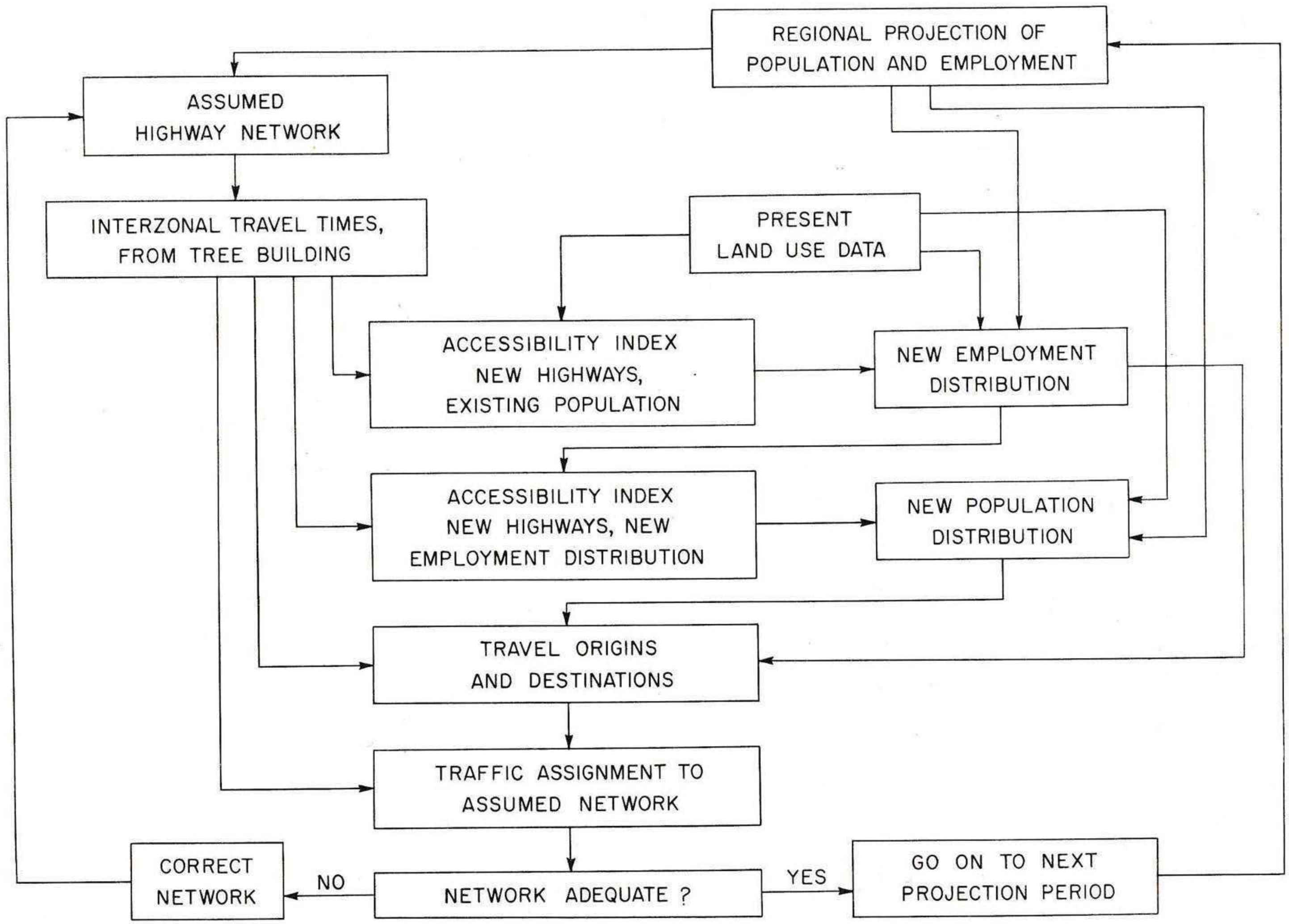



FIGURE XVI

trips are calculated and thence into the traffic assignment. It is seen that in virtually every phase of the analysis, including the land use, travel-time information is required. One key to the process then is the tree building program, used to develop the inter-zonal travel times and trip traces. This information is used first in the land use analysis for calculating the accessibility indices, and again in the gravity model for calculating the distribution of trips. Finally the trip traces recorded during the tree building process are used in the assignment program for cumulating the link volumes.

The feedback, previously mentioned, which is so important to the process, is readily apparent from this diagram also, for it is obvious that a major change in the highway network, such as the addition of a new expressway route, will have a profound effect upon the entire process.

## IV. ANALYSIS OF STUDY FINDINGS

### A. Projections

Since highway improvements are constructed to serve traffic for a long period of time they are planned with adequate capacity to accommodate the traffic which is anticipated many years in the future. As indicated previously, HATS has made analyses of not only 1975, the Interstate design year, but also 1990, the Department design year, and the horizon year as well. Dealing for the moment with 1975 only, analyses show there will be nearly half a million vehicles in the study area in that year -- almost one for every two persons. It is estimated that these vehicles will travel 16-3/4 million miles on the average day in 1975, double the present rate -- enough mileage every day to circle the earth 700 times.

Comparing 1975 with 1960 an increase of 8.34 million vehicle miles per day can be expected. Since most of the arterial streets in the area are now operating at or near capacity, the majority of this increase must be handled by increased capacity of the highway system. If this increase were to be carried exclusively on four-lane expressways, over 200 miles would have to be constructed to serve the increased demand.

These factors scale the problem; in order to determine quantitatively where the added capacity will be needed and in what form it should be provided, more detailed analyses are required.

### B. Analysis of Traffic Growth Comparisons

Of great concern to the researchers was the comparison of the growth factors for the various units of measurement. Actually, a great deal of information can be derived from these; not only can the over-all growth be checked but also the adequacy and efficiency of the proposed system can be estimated. In effect, we have a picture of the future area in terms of the transportation network.

One of the great advantages of the mathematical method of analysis is that all assumptions, source data, and subsequent findings are recorded during the process. A wealth of information not normally obtained is available for analysis which gives very close and detailed checks of the projection process. Shown below in Tables 7 and 8 are some of the growth comparisons.

TABLE 7

SCREEN LINE GROWTH COMPARISON
1960 to 1975 -- ON BASIS OF GROUP TO GROUP TOTALS
Average Daily Vehicles Crossing -- Thousands of Vehicles

| Screen Line | 1960 | 1975 | 1975/1960 |
|---|---|---|---|
| 1 | 89.2 | 264.8 | 2.95 |
| 2 | 160.0 | 336.6 | 2.10 |
| 3 | 70.5 | 138.5 | 1.96 |
| A | 162.3 | 321.5 | 1.98 |
| B | 180.7 | 390.9 | 2.16 |
| Total | 662.7 | 1452.3 | 2.19 (Average) |

TABLE 8

GROWTH COMPARISON
1960 to 1975 -- Millions of Units

| Factor | 1960 | 1975 | 1975/1960 |
|---|---|---|---|
| Screen Line Crossings | 0.6627 | 1.4523 | 2.19 |
| Desire Lines (Average Daily Vehicle Miles) | 6.01 | 11.26 | 1.87 |
| Network Assignment (Average Daily Vehicle Miles) | 8.41 | 16.75 | 1.99 |
| Network Assignment (Average Daily Vehicle Minutes) | 16.20 | 25.07 | 1.55 |
| Population | 0.752 | 1.026 | 1.37 |
| Cars | 0.297 | 0.497 | 1.61 |
| Trips | 1.514 | 2.258 | 1.57 |

1. Difference in Vehicle Miles -- Desire Line Assignment versus Network Assignment

The difference in Vehicle Miles as determined by the alternate methods of assignment is due primarily to the fact that the highway network does not and cannot represent the straight line distance between origin and destination as the desire lines do. The network system necessitates out-of-direction travel in most situations. In the conversion of desire lines to the network system, this out-of-direction travel is unavoidable. Studies have shown that motorists are willing to travel greater distances in order to save travel time and to use the safer, free moving expressway facilities.

It is interesting to note that in 1960 the ratio of network to desire line assignments is 1.4 whereas in 1975 the ratio is expected to be 1.49. This indicates that the new expressways will do an excellent job of serving the travel desires in comparison to the existing network. This is particularly true when it is recognized that a quasi-capacity restraint has been applied to I. 84 which causes out-of-direction travel for many movements.

2. Difference Between Increase in Vehicle Miles and Vehicle Minutes

The fact that the vehicle minutes of travel will increase only 55% whereas the vehicle miles will increase 99% shows that the proposed expressway network will be serving the majority of the major traffic movements. This again in spite of the cost of out-of-direction travel necessitated by lack of capacity on I. 84.

It is interesting to note that in this period the population is expected to increase 37%. With only a 55% increase in vehicle minutes of travel, individuals will spend only slightly more time in autos than they do today. Further, since vehicle ownership is expected to increase faster than vehicle minutes, the average time on the road per vehicle will actually decrease.

The Chicago Area Transportation Study used travel time per person as the major control. Although HATS held trips per car constant over time and related trip length to travel time, nearly the same over-all affect is obtained.

3. Difference in Growth between Car Ownership and Trip Production

For three of the four trip purposes, trip production is related directly to car ownership and therefore a change in car ownership will result in exactly the same change in the number of trips. However, an increase in car ownership will not necessarily result in an increase in the number of work trips. Therefore, work trip production was related to labor force and not car ownership. The actual work trips per car were: 1.14 and 0.92 for 1960 and 1975 respectively.

4. Difference in Growth between Trips and Vehicle Miles of Travel

Whereas the number of trips will increase 57% in 15 years, the vehicle miles of travel will increase 99%. This difference is due primarily to two causes: (1) dispersal of population caused by the "flight to suburbia", and (2) longer trip lengths in general. This is compatible with past experience which shows that as people have more leisure time, more spending money, and better highways, they will travel farther. It should be noted that this measure reflects out-of-direction travel caused by diversion to new expressways.

5. Summary of Traffic Growth Factors

Unlike a linear route problem which is concerned with only a single growth factor, a traffic study of this type contains numerous different and diverse factors. At times it is difficult to differentiate the independent and dependent variables. Of primary concern is the over-all increase in traffic as measured by the desire line assignment. Although this variable is dependent upon population and increase in car ownership, it is neverthe-

less the value which is ultimately assigned to the network and upon which the new routes are designed. Therefore the most representative measurement of the over-all increase in traffic is the desire line vehicle mile increase since it includes all the variables except out-of-direction travel caused by the new expressways. The other measures of traffic growth are therefore only dependent variables and of lesser value in measuring over-all growth.

C. Analysis of Land Use Growth

The population of the Study Area will increase from 752,200 in 1960 to approximately 1,026,000 in 1975. Estimates of growth beyond 1975 indicate a 1990 population of 1,399,560 and a horizon year population of 1,919,000. These values are portrayed graphically on Figure XVII.

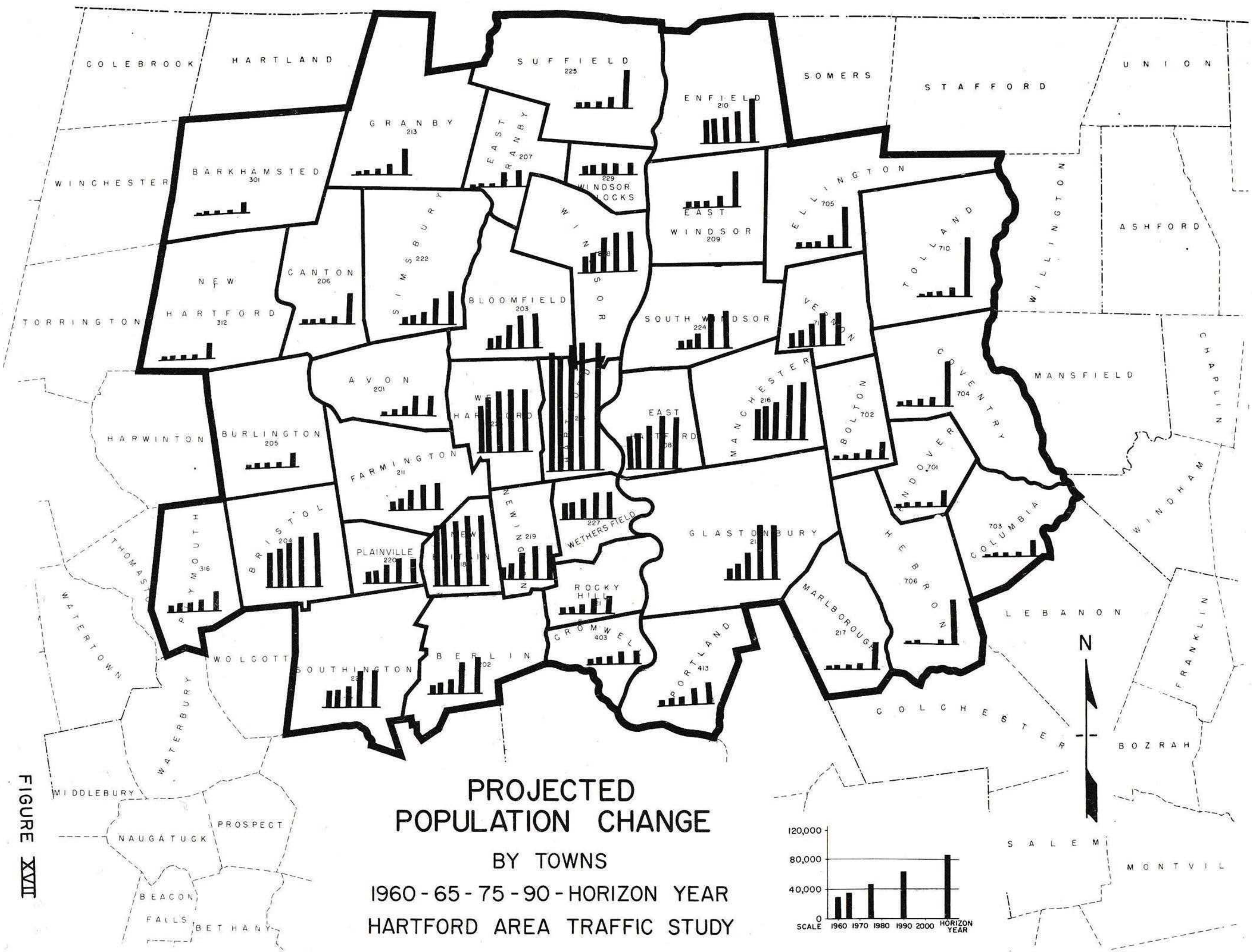
The detailed breakdown of these population projections as well as the estimate of the other land use information required for the gravity model computations, as developed by the land use model, are included in the appendix.

It is seen from Figure XVII that the majority of the population increase will occur in the outlying areas, those which are today primarily undeveloped. This is to be expected. Further, it is seen that in most cases, although not completely, the growth is spreading outward from the center, filling the closer towns nearly to capacity before the succeeding towns receive appreciable growth. This also is to be expected.

It stands to reason, therefore, that in the near future, most of the highway construction activity should be concentrated close to the metropolitan center, leaving until later years the construction of outlying routes. Basically this is the plan which is today being followed.

D. Analysis of Trip Production and Attraction

It is estimated that the trips within the study area will increase from a 1960 value of 1,514,000 to 2,258,000 in 1975. The increase in trip




PROJECTED
POPULATION CHANGE
BY TOWNS
1960 - 65 - 75 - 90 - HORIZON YEAR
HARTFORD AREA TRAFFIC STUDY

FIGURE XVII

production, as explained previously, is related primarily to the population and as such will show nearly the same growth patterns. Trip attraction, on the other hand, is related more closely to employment and shopping opportunities.

Shown in Table 9 below are the total trip productions, by trip purpose, within the study area for various years. Although the land use model was calculated for 1965, in order to shorten the projection process, the Gravity Model was eliminated for that year. Therefore no trip data is presented for 1965.

TABLE 9
TOTAL TRIP PRODUCTIONS

| Trip Purpose | 1960 | 1975 | 1990 |
|---|---|---|---|
| Work | 350,500 | 441,300 | 607,600 |
| Social | 240,000 | 380,000 | 540,400 |
| Commercial | 316,500 | 479,000 | 676,100 |
| Non-home Based | 606,800 | 958,000 | 1,013,200 |
| Total | 1,513,800 | 2,258,300 | 2,837,300 |

## V. INTERIM SUMMARY

At this point in the report it is felt that a temporary ending should be affected. The information presented thus far pertains to the methods and procedures used in the study and the analysis of the factors involved.

At present, analyses of the traffic assignments for the different study periods are not complete; therefore results cannot be quoted, nor can final recommendations be made.

This report illustrates how a land use analysis is applied to an assumed population growth and an employment forecast, to obtain the distribution of the predicted population, car ownership, and the various employment categories. The application of the Gravity Model theory results in the distribution of the trips generated by the various land use categories. The culmination of this process achieves the ultimate objective of the study -- to convert the generated traffic volumes into an integrated pattern of resultant traffic desires.

To summarize briefly, by utilizing an assumed population growth; the land use pattern, the traffic volumes developed by this land use pattern, and the traffic desires between trip generators and attractors have been predicted on the basis of mathematical formulae.

# APPENDIX

7-13-61

# HARTFORD AREA TRAFFIC STUDY CODE SHEET

| Town No. | Computer Code | Town Name |
|---|---|---|
| 201 | 16 | Avon |
| 202 | 32 | Berlin |
| 203 - 01 | 48 | Bloomfield |
| 02 | 64 | |
| 03 | 80 | |
| 04 | 96 | |
| 204 | 112 | Bristol |
| 205 | 128 | Burlington |
| 206 | 144 | Canton |
| 207 | 160 | East Granby |
| 208 - 01 | 176 | East Hartford |
| 02 | 192 | |
| 03 | 208 | |
| 04 | 224 | |
| 05 | 240 | |
| 209 | 256 | East Windsor |
| 210 - 01 | 272 | Enfield |
| 02 | 288 | |
| 211 | 304 | Farmington |
| 212 | 320 | Glastonbury |
| 213 | 336 | Granby |
| 214 - 01 | 352 | Hartford |
| 02 | 368 | |
| 03 | 384 | |
| 04 | 400 | |
| 05 | 416 | |
| 06 | 432 | |
| 07 | 448 | |
| 08 | 464 | |
| 09 | 480 | |
| 10 | 496 | |
| 11 | 512 | |
| 12 | 528 | |
| 13 | 544 | |
| 14 | 560 | |
| 15 | 576 | |
| 16 | 592 | |
| 17 | 608 | |
| 18 | 624 | |
| 19 | 640 | |
| 20 | 656 | |
| 21 | 672 | |
| 22 | 688 | |
| 23 | 704 | |
| 24 | 720 | |
| 25 | 736 | |
| 26 | 752 | |
| 27 | 768 | |
| 216 - 01 | 784 | Manchester |
| 02 | 800 | |
| 03 | 816 | |
| 04 | 832 | |
| 05 | 848 | |
| 06 | 864 | |
| 217 | 880 | Marlborough |
| 218 - 01 | 896 | New Britain |
| 02 | 912 | |
| 03 | 928 | |
| 04 | 944 | |
| 05 | 960 | |

| Town No. | Computer Code | Town Name |
|---|---|---|
| 218 - 06 | 976 | |
| 07 | 992 | |
| 08 | 1008 | |
| 09 | 1024 | |
| 219 - 01 | 1040 | Newington |
| 02 | 1056 | |
| 03 | 1072 | |
| 04 | 1088 | |
| 05 | 1104 | |
| 220 | 1120 | Plainville |
| 221 - 01 | 1136 | Rocky Hill |
| 02 | 1152 | |
| 222 | 1168 | Simsbury |
| 223 | 1184 | Southington |
| 224 | 1200 | So. Windsor |
| 225 | 1216 | Suffield |
| 226 - 01 | 1232 | West Hartford |
| 02 | 1248 | |
| 03 | 1264 | |
| 04 | 1280 | |
| 05 | 1296 | |
| 06 | 1312 | |
| 07 | 1328 | |
| 227 - 01 | 1344 | Wethersfield |
| 02 | 1360 | |
| 03 | 1376 | |
| 228 - 01 | 1392 | Windsor |
| 02 | 1408 | |
| 03 | 1424 | |
| 229 - 01 | 1440 | Windsor Locks |
| 02 | 1456 | |
| 301 | 1472 | Barkhamsted |
| 312 | 1488 | New Hartford |
| 316 | 1504 | Plymouth |
| 403 | 1520 | Cromwell |
| 413 | 1536 | Portland |
| 701 | 1552 | Andover |
| 702 | 1568 | Bolton |
| 703 | 1584 | Columbia |
| 704 | 1600 | Coventry |
| 705 | 1616 | Ellington |
| 706 | 1632 | Hebron |
| 710 | 1648 | Tolland |
| 712 - 01 | 1664 | Vernon |
| 02 | 1680 | |
| 801 | 2000 | Springfield |
| 802 | 2016 | Somers |
| 803 | 2032 | Boston |
| 804 | 2048 | Mansfield |
| 805 | 2064 | Willimantic |
| 806 | 2080 | New London |
| 807 | 2096 | Middletown |
| 808 | 2112 | New Haven |
| 809 | 2128 | Cheshire |
| 810 | 2144 | Waterbury |
| 811 | 2160 | Thomaston |
| 812 | 2176 | Harwinton |
| 813 | 2192 | Torrington |
| 814 | 2208 | Pittsfield |

HARTFORD AREA TRAFFIC STUDY
1960 BASIC DATA 1960

| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 201 | 16 | 5250 | 1630 | 90 | 160 | 170 | 420 | 2760 |
| 202 | 32 | 11250 | 3490 | 1490 | 1400 | 570 | 3460 | 4870 |
| 203 - 01 | 48 | 6750 | 2090 | 130 | 390 | 170 | 690 | 3150 |
| 02 | 64 | 3300 | 1020 | 100 | 750 | 120 | 970 | 1500 |
| 03 | 80 | 1150 | 370 | 100 | 0 | 0 | 100 | 500 |
| 04 | 96 | 2300 | 710 | 50 | 1450 | 0 | 1500 | 1090 |
| 203 Total | | 13500 | 4190 | 380 | 2590 | 290 | 3260 | 7240 |
| 204 | 112 | 45350 | 14510 | 2220 | 8820 | 1470 | 12510 | 16300 |
| 205 | 128 | 2750 | 850 | 10 | 10 | 0 | 20 | 1260 |
| 206 | 144 | 4800 | 1440 | 70 | 340 | 90 | 500 | 2160 |
| 207 | 160 | 2450 | 780 | 30 | 0 | 80 | 110 | 1390 |
| 208 - 01 | 176 | 11900 | 5410 | 1150 | 1000 | 1200 | 3350 | 4400 |
| 02 | 192 | 6700 | 1880 | 3040 | 24590 | 1250 | 28880 | 2880 |
| 03 | 208 | 7650 | 2450 | 430 | 300 | 300 | 1030 | 3800 |
| 04 | 224 | 10050 | 2810 | 680 | 0 | 290 | 970 | 6140 |
| 05 | 240 | 7550 | 2270 | 200 | 200 | 1100 | 1500 | 3960 |
| 208 Total | | 43850 | 14820 | 5500 | 26090 | 4140 | 35730 | 21180 |
| 209 | 256 | 7500 | 2330 | 130 | 650 | 210 | 990 | 4360 |
| 210 - 01 | 272 | 10300 | 3610 | 2300 | 1300 | 430 | 4030 | 3720 |
| 02 | 288 | 21150 | 6560 | 780 | 0 | 1100 | 1880 | 9200 |
| 210 Total | | 31450 | 10170 | 3080 | 1300 | 1530 | 5910 | 12920 |
| 211 | 304 | 10800 | 3240 | 610 | 560 | 440 | 1610 | 5120 |
| 212 | 320 | 14450 | 4330 | 620 | 600 | 360 | 1580 | 6950 |
| 213 | 336 | 4950 | 1530 | 20 | 10 | 70 | 100 | 2770 |
| 214 - 01 | 352 | 6850 | 2470 | 1330 | 0 | 660 | 1990 | 1700 |
| 02 | 368 | 5550 | 2220 | 1890 | 0 | 600 | 2490 | 1390 |
| 03 | 384 | 5350 | 2030 | 790 | 1220 | 420 | 2430 | 1190 |
| 04 | 400 | 350 | 140 | 8800 | 1020 | 4320 | 14140 | 570 |
| 05 | 416 | 2100 | 710 | 680 | 400 | 400 | 1480 | 560 |
| 06 | 432 | 50 | 20 | 350 | 200 | 0 | 550 | 100 |
| 07 | 448 | 50 | 20 | 400 | 400 | 0 | 800 | 300 |
| 08 | 464 | 6050 | 1880 | 520 | 220 | 420 | 1160 | 700 |
| 09 | 480 | 5950 | 2020 | 1830 | 550 | 90 | 2470 | 1680 |
| 10 | 496 | 10750 | 3330 | 720 | 0 | 330 | 1050 | 2220 |
| 11 | 512 | 8950 | 3130 | 1470 | 220 | 1320 | 3010 | 3050 |
| 12 | 528 | 7950 | 2780 | 940 | 20 | 810 | 1770 | 1500 |
| 13 | 544 | 4400 | 1980 | 8350 | 700 | 4760 | 13810 | 2330 |
| 14 | 560 | 2350 | 1060 | 3180 | 0 | 480 | 3660 | 820 |
| 15 | 576 | 9700 | 3390 | 830 | 0 | 430 | 1260 | 3460 |
| 16 | 592 | 7800 | 2650 | 1170 | 250 | 720 | 2140 | 2090 |
| 17 | 608 | 0 | 0 | 250 | 300 | 0 | 550 | 0 |
| 18 | 624 | 0 | 0 | 600 | 1500 | 0 | 2100 | 0 |
| 19 | 640 | 5200 | 1770 | 890 | 100 | 290 | 1280 | 1620 |
| 20 | 656 | 10750 | 3980 | 1350 | 550 | 1840 | 3740 | 2390 |
| 21 | 672 | 6250 | 2630 | 6480 | 6000 | 560 | 13040 | 1650 |
| 22 | 688 | 5600 | 2520 | 3020 | 1760 | 50 | 4830 | 1140 |
| 23 | 704 | 13050 | 4050 | 450 | 0 | 320 | 770 | 4440 |
| 24 | 720 | 5100 | 1840 | 380 | 10100 | 350 | 10830 | 1330 |
| 25 | 736 | 10150 | 3860 | 1570 | 0 | 590 | 2160 | 3240 |
| 26 | 752 | 14650 | 4400 | 490 | 0 | 240 | 730 | 3060 |
| 27 | 768 | 6100 | 2010 | 370 | 2850 | 70 | 3290 | 1900 |
| 214 Total | | 161050 | 56890 | 49100 | 28360 | 20070 | 97530 | 44430 |

HARTFORD AREA TRAFFIC STUDY
1960 BASIC DATA 1960

| Zone | | Popu- | Labor | Employment | | | | Car |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | lation | Force | Service | Mfg. | Retail | Total | Owner-ship |
| 216 - 01 | 784 | 1700 | 560 | 50 | 450 | 0 | 500 | 370 |
| 02 | 800 | 2450 | 810 | 210 | 1400 | 130 | 1740 | 740 |
| 03 | 816 | 13800 | 4550 | 1690 | 550 | 480 | 2720 | 4740 |
| 04 | 832 | 16050 | 5300 | 110 | 0 | 620 | 730 | 5860 |
| 05 | 848 | 3950 | 1300 | 1620 | 420 | 1020 | 3060 | 2470 |
| 06 | 864 | 3950 | 1300 | 200 | 0 | 170 | 370 | 2880 |
| 216 Total | | 41900 | 13820 | 3880 | 2820 | 2420 | 9120 | 17060 |
| 217 | 880 | 1950 | 590 | 0 | 30 | 60 | 90 | 1000 |
| 218 - 01 | 896 | 2450 | 860 | 1310 | 950 | 2690 | 4950 | 580 |
| 02 | 912 | 10450 | 3660 | 1030 | 950 | 240 | 2220 | 2450 |
| 03 | 928 | 8700 | 3040 | 580 | 3300 | 240 | 4120 | 2050 |
| 04 | 944 | 2600 | 910 | 300 | 3600 | 100 | 4000 | 860 |
| 05 | 960 | 3750 | 1310 | 320 | 5540 | 120 | 5980 | 2300 |
| 06 | 976 | 14350 | 5020 | 660 | 1250 | 120 | 2030 | 4600 |
| 07 | 992 | 16200 | 5670 | 480 | 250 | 170 | 900 | 4200 |
| 08 | 1008 | 11400 | 3990 | 350 | 3000 | 100 | 3450 | 3530 |
| 09 | 1024 | 11700 | 4100 | 250 | 200 | 100 | 550 | 3500 |
| 218 Total | | 81600 | 28560 | 5280 | 19040 | 3880 | 28200 | 24070 |
| 219 - 01 | 1040 | 4050 | 1260 | 380 | 300 | 100 | 780 | 1860 |
| 02 | 1056 | 1950 | 620 | 480 | 1270 | 40 | 1790 | 890 |
| 03 | 1072 | 3250 | 1040 | 200 | 250 | 70 | 520 | 1500 |
| 04 | 1088 | 4950 | 1530 | 470 | 0 | 270 | 740 | 2260 |
| 05 | 1104 | 3250 | 1010 | 460 | 350 | 170 | 980 | 1420 |
| 219 Total | | 17450 | 5460 | 1990 | 2170 | 650 | 4810 | 7930 |
| 220 | 1120 | 13100 | 4060 | 300 | 4010 | 440 | 4750 | 5600 |
| 221 - 01 | 1136 | 2700 | 920 | 50 | 600 | 90 | 740 | 1130 |
| 02 | 1152 | 4650 | 1390 | 390 | 180 | 110 | 680 | 2000 |
| 221 Total | | 7350 | 2310 | 440 | 780 | 200 | 1420 | 3130 |
| 222 | 1168 | 10100 | 3130 | 370 | 330 | 600 | 1300 | 4650 |
| 223 | 1184 | 22800 | 7070 | 500 | 5000 | 920 | 6420 | 10900 |
| 224 | 1200 | 9350 | 2900 | 50 | 140 | 300 | 490 | 4200 |
| 225 | 1216 | 6750 | 2030 | 70 | 140 | 120 | 330 | 4900 |
| 226 - 01 | 1232 | 1250 | 380 | 30 | 0 | 40 | 70 | 630 |
| 02 | 1248 | 24250 | 8250 | 670 | 0 | 960 | 1630 | 11000 |
| 03 | 1264 | 900 | 300 | 1680 | 0 | 1110 | 2790 | 430 |
| 04 | 1280 | 13050 | 3920 | 120 | 0 | 400 | 520 | 5160 |
| 05 | 1296 | 18850 | 6220 | 270 | 120 | 480 | 870 | 6400 |
| 06 | 1312 | 2650 | 870 | 1230 | 7700 | 220 | 9150 | 1170 |
| 07 | 1328 | 1250 | 370 | 50 | 0 | 20 | 70 | 630 |
| 226 Total | | 62200 | 20310 | 4050 | 7820 | 3230 | 15100 | 25420 |
| 227 - 01 | 1344 | 4050 | 1220 | 110 | 0 | 90 | 200 | 1750 |
| 02 | 1360 | 11850 | 3670 | 770 | 390 | 590 | 1750 | 5100 |
| 03 | 1376 | 4600 | 1380 | 20 | 150 | 90 | 260 | 1920 |
| 227 Total | | 20500 | 6270 | 900 | 540 | 770 | 2210 | 8770 |
| 228 - 01 | 1392 | 6450 | 2000 | 80 | 400 | 100 | 580 | 2270 |
| 02 | 1408 | 7070 | 2190 | 650 | 200 | 20 | 870 | 2830 |
| 03 | 1424 | 5900 | 1770 | 100 | 1930 | 250 | 2280 | 2620 |
| 228 Total | | 19420 | 5960 | 830 | 2530 | 370 | 3730 | 7720 |
| 229 - 01 | 1440 | 1150 | 380 | 950 | 6500 | 100 | 7550 | 550 |
| 02 | 1456 | 10250 | 3180 | 500 | 750 | 520 | 1770 | 4500 |
| 229 Total | | 11400 | 3560 | 1450 | 7250 | 620 | 9320 | 5050 |

HARTFORD AREA TRAFFIC STUDY

1960 BASIC DATA 1960

| Zone: Town Code | Zone: Comp. Code | Population | Labor Force | Employment: Service | Employment: Mfg. | Employment: Retail | Employment: Total | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| 301 | 1472 | 1350 | 390 | 80 | 120 | 30 | 230 | 740 |
| 312 | 1488 | 3000 | 960 | 70 | 60 | 20 | 150 | 1460 |
| 316 | 1504 | 8950 | 2950 | 100 | 1380 | 130 | 1610 | 4050 |
| 403 | 1520 | 6750 | 2230 | 100 | 70 | 90 | 260 | 3170 |
| 413 | 1536 | 7450 | 2160 | 420 | 780 | 390 | 1590 | 3430 |
| 701 | 1552 | 1750 | 530 | 70 | 60 | 40 | 170 | 900 |
| 702 | 1568 | 2950 | 970 | 20 | 30 | 60 | 110 | 1800 |
| 703 | 1584 | 2150 | 650 | 30 | 60 | 50 | 140 | 1210 |
| 704 | 1600 | 6500 | 2020 | 160 | 10 | 50 | 220 | 3330 |
| 705 | 1616 | 5600 | 1790 | 30 | 10 | 60 | 100 | 4170 |
| 706 | 1632 | 1850 | 590 | 20 | 10 | 30 | 60 | 1060 |
| 710 | 1648 | 2900 | 870 | 30 | 0 | 70 | 100 | 1760 |
| 712 - 01 | 1664 | 9500 | 3230 | 830 | 1140 | 220 | 2190 | 3000 |
| 02 | 1680 | 7500 | 2330 | 430 | 270 | 230 | 930 | 2840 |
| 712 Total | | 17000 | 5560 | 1260 | 1410 | 450 | 3120 | 5840 |
| Total Internal | | 753470 | 247900 | 85850 | 127490 | 45540 | 258880 | 296730 |
| 801 | 2000 | 420000 | | 126000 | | 42000 | 168000 | |
| 802 | 2016 | 21000 | | 6300 | | 2100 | 8400 | |
| 803 | 2032 | 42000 | | 12600 | | 4200 | 16800 | |
| 804 | 2048 | 10500 | | 3150 | | 1050 | 4200 | |
| 805 | 2064 | 42000 | | 12600 | | 4200 | 16800 | |
| 806 | 2080 | 42000 | | 12600 | | 4200 | 16800 | |
| 807 | 2096 | 42000 | | 12600 | | 4200 | 16800 | |
| 808 | 2112 | 420000 | | 126000 | | 42000 | 168000 | |
| 809 | 2128 | 42000 | | 12600 | | 4200 | 16800 | |
| 810 | 2144 | 210000 | | 63000 | | 21000 | 84000 | |
| 811 | 2160 | 31500 | | 9450 | | 3150 | 12600 | |
| 812 | 2176 | 52500 | | 15750 | | 5250 | 21000 | |
| 813 | 2192 | 31500 | | 9450 | | 3150 | 12600 | |
| 814 | 2208 | 21000 | | 6300 | | 2100 | 8400 | |
| Total External | | 1428000 | --- | 428400 | | 142800 | 571200 | --- |
| GRAND TOTAL | | 2181470 | 247900 | 641740 | | 188340 | 830080 | 296730 |

HARTFORD AREA TRAFFIC STUDY
1965 BASIC DATA 1965

November 23, 1960



| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 201 | 16 | 6910 | 2140 | 110 | 320 | 300 | 730 | 4050 |
| 202 | 32 | 12910 | 4000 | 1560 | 1890 | 700 | 4150 | 6430 |
| 203 - 01 | 48 | 6840 | 2120 | 170 | 450 | 180 | 800 | 5000 |
| - 02 | 64 | 3630 | 1120 | 600 | 750 | 170 | 1520 | 2490 |
| - 03 | 80 | 1780 | 570 | 100 | 0 | 0 | 100 | 870 |
| - 04 | 96 | 3670 | 1140 | 50 | 2250 | 130 | 2430 | 1720 |
| 203 Total | | 15920 | 4950 | 920 | 3450 | 480 | 4850 | 10080 |
| 204 | 112 | 49540 | 15850 | 2430 | 9010 | 1810 | 13250 | 20630 |
| 205 | 128 | 2930 | 910 | 0 | 90 | 10 | 100 | 1560 |
| 206 | 144 | 5130 | 1540 | 80 | 420 | 120 | 620 | 2680 |
| 207 | 160 | 3030 | 970 | 30 | 110 | 130 | 270 | 1750 |
| 208 - 01 | 176 | 13060 | 4180 | 2400 | 1200 | 1300 | 4900 | 5640 |
| 02 | 192 | 6780 | 1900 | 3230 | 25190 | 1340 | 29760 | 3360 |
| 03 | 208 | 8270 | 2650 | 490 | 350 | 350 | 1190 | 4070 |
| 04 | 224 | 11120 | 3110 | 730 | 0 | 290 | 1020 | 6640 |
| 05 | 240 | 8300 | 2490 | 390 | 600 | 1160 | 2150 | 4230 |
| 208 Total | | 47530 | 14330 | 7240 | 27340 | 4440 | 39020 | 23940 |
| 209 | 256 | 8050 | 2500 | 150 | 850 | 250 | 1250 | 4820 |
| 210 - 01 | 272 | 10400 | 3640 | 2330 | 1350 | 440 | 4120 | 4330 |
| 02 | 288 | 22030 | 6830 | 850 | 400 | 1170 | 2420 | 10810 |
| 210 Total | | 32430 | 10470 | 3180 | 1750 | 1610 | 6540 | 15140 |
| 211 | 304 | 14780 | 4430 | 690 | 850 | 760 | 2300 | 7440 |
| 212 | 320 | 19900 | 5970 | 670 | 730 | 800 | 2200 | 9990 |
| 213 | 336 | 5330 | 1650 | 30 | 180 | 100 | 310 | 3210 |
| 214 - 01 | 352 | 6950 | 2500 | 1470 | 0 | 670 | 2140 | 1990 |
| 02 | 368 | 6020 | 2410 | 2020 | 0 | 640 | 2660 | 1740 |
| 03 | 384 | 5440 | 2070 | 880 | 1130 | 430 | 2440 | 1400 |
| 04 | 400 | 1900 | 760 | 9720 | 720 | 4420 | 14860 | 550 |
| 05 | 416 | 500 | 170 | 770 | 400 | 260 | 1430 | 140 |
| 06 | 432 | 0 | 0 | 350 | 700 | 0 | 1050 | 0 |
| 07 | 448 | 0 | 0 | 400 | 900 | 0 | 1300 | 0 |
| 08 | 464 | 5500 | 1710 | 610 | 220 | 370 | 1200 | 640 |
| 09 | 480 | 6420 | 2180 | 1850 | 550 | 130 | 2530 | 1950 |
| 10 | 496 | 11640 | 3610 | 790 | 0 | 400 | 1190 | 2820 |
| 11 | 512 | 8000 | 2800 | 1760 | 220 | 1320 | 3300 | 2380 |
| 12 | 528 | 7500 | 2630 | 1150 | 20 | 770 | 1940 | 1600 |
| 13 | 544 | 5190 | 2340 | 9050 | 700 | 4510 | 14260 | 1580 |
| 14 | 560 | 2000 | 900 | 3290 | 0 | 450 | 3740 | 590 |
| 15 | 576 | 9880 | 3460 | 920 | 0 | 440 | 1360 | 3900 |
| 16 | 592 | 7890 | 2680 | 1330 | 250 | 730 | 2310 | 2350 |
| 17 | 608 | 730 | 250 | 250 | 300 | 60 | 610 | 220 |
| 18 | 624 | 0 | 0 | 600 | 2000 | 0 | 2600 | 0 |
| 19 | 640 | 5300 | 1800 | 960 | 100 | 300 | 1360 | 1580 |
| 20 | 656 | 8000 | 2960 | 1650 | 450 | 1880 | 3980 | 1920 |
| 21 | 672 | 6000 | 2520 | 6620 | 5700 | 540 | 12860 | 1820 |
| 22 | 688 | 5500 | 2480 | 3030 | 1760 | 40 | 4830 | 1280 |
| 23 | 704 | 13470 | 4180 | 510 | 0 | 350 | 860 | 4060 |
| 24 | 720 | 4500 | 1620 | 460 | 10200 | 300 | 10960 | 1350 |
| 25 | 736 | 10000 | 3800 | 1710 | 0 | 580 | 2290 | 3670 |
| 26 | 752 | 14890 | 4470 | 540 | 0 | 260 | 800 | 3620 |
| 27 | 768 | 5500 | 1820 | 380 | 2250 | 20 | 2650 | 1890 |
| 214 Total | | 158720 | 56120 | 53070 | 28570 | 19870 | 101510 | 45040 |

| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 216 - 01 | 784 | 2460 | 800 | 50 | 850 | 60 | 960 | 810 |
| 02 | 800 | 2690 | 890 | 230 | 1790 | 150 | 2170 | 970 |
| 03 | 816 | 14370 | 4740 | 1870 | 550 | 520 | 2940 | 5740 |
| 04 | 832 | 16450 | 5430 | 190 | 0 | 660 | 850 | 6940 |
| 05 | 848 | 4030 | 1330 | 1770 | 420 | 1030 | 3220 | 2420 |
| 06 | 864 | 5120 | 1690 | 230 | 0 | 260 | 490 | 3060 |
| 216 Total | | 45120 | 14880 | 4340 | 3610 | 2680 | 10630 | 19940 |
| 217 | 880 | 2430 | 730 | 10 | 80 | 100 | 190 | 1440 |
| 218 - 01 | 896 | 2540 | 890 | 1610 | 950 | 2700 | 5260 | 700 |
| 02 | 912 | 10730 | 3760 | 1080 | 950 | 260 | 2290 | 2900 |
| 03 | 928 | 9010 | 3150 | 630 | 3300 | 260 | 4190 | 2450 |
| 04 | 944 | 2640 | 920 | 320 | 3600 | 100 | 4020 | 790 |
| 05 | 960 | 3860 | 1350 | 350 | 5540 | 130 | 6020 | 1820 |
| 06 | 976 | 14570 | 5100 | 680 | 1250 | 140 | 2070 | 5390 |
| 07 | 992 | 16410 | 5740 | 510 | 250 | 190 | 950 | 4920 |
| 08 | 1008 | 11620 | 4070 | 370 | 3120 | 120 | 3610 | 4150 |
| 09 | 1024 | 12030 | 4210 | 170 | 230 | 130 | 530 | 4160 |
| 218 Total | | 83410 | 29190 | 5720 | 19190 | 4030 | 28940 | 27280 |
| 219 - 01 | 1040 | 4710 | 1460 | 400 | 350 | 150 | 900 | 2350 |
| 02 | 1056 | 3050 | 980 | 490 | 1870 | 130 | 2490 | 1510 |
| 03 | 1072 | 4460 | 1430 | 220 | 350 | 170 | 740 | 2240 |
| 04 | 1088 | 5590 | 1730 | 530 | 0 | 320 | 850 | 2770 |
| 05 | 1104 | 5930 | 1840 | 490 | 370 | 380 | 1240 | 2940 |
| 219 Total | | 23740 | 7440 | 2130 | 2940 | 1150 | 6220 | 11810 |
| 220 | 1120 | 14250 | 4420 | 360 | 4550 | 530 | 5440 | 7010 |
| 221 - 01 | 1136 | 3130 | 1060 | 60 | 750 | 120 | 930 | 1520 |
| 02 | 1152 | 5630 | 1690 | 410 | 230 | 190 | 830 | 2790 |
| 221 Total | | 8760 | 2750 | 470 | 980 | 310 | 1760 | 4310 |
| 222 | 1168 | 11920 | 3700 | 430 | 490 | 750 | 1670 | 6440 |
| 223 | 1184 | 24420 | 7570 | 600 | 6080 | 1050 | 7730 | 12200 |
| 224 | 1200 | 11820 | 3660 | 90 | 300 | 500 | 890 | 5870 |
| 225 | 1216 | 7010 | 2100 | 70 | 270 | 140 | 480 | 4180 |
| 226 - 01 | 1232 | 1330 | 400 | 30 | 0 | 40 | 70 | 660 |
| 02 | 1248 | 29570 | 10050 | 860 | 0 | 1390 | 2250 | 14820 |
| 03 | 1264 | 500 | 170 | 1970 | 0 | 1100 | 3070 | 250 |
| 04 | 1280 | 16700 | 5010 | 210 | 0 | 690 | 900 | 7760 |
| 05 | 1296 | 20420 | 6740 | 500 | 0 | 600 | 1100 | 8140 |
| 06 | 1312 | 2500 | 830 | 1280 | 8650 | 210 | 10140 | 1610 |
| 07 | 1328 | 1480 | 440 | 50 | 0 | 20 | 70 | 650 |
| 226 Total | | 72500 | 23640 | 4900 | 8650 | 4050 | 17600 | 33890 |
| 227 - 01 | 1344 | 4000 | 1200 | 130 | 0 | 90 | 220 | 1990 |
| 02 | 1360 | 12460 | 3860 | 1170 | 560 | 540 | 2270 | 6170 |
| 03 | 1376 | 6150 | 1850 | 40 | 350 | 210 | 600 | 2980 |
| 227 Total | | 22610 | 6910 | 1340 | 910 | 840 | 3090 | 11140 |
| 228 - 01 | 1392 | 7580 | 2350 | 100 | 440 | 190 | 730 | 3760 |
| 02 | 1408 | 8040 | 2490 | 660 | 260 | 90 | 1010 | 3740 |
| 03 | 1424 | 9110 | 2730 | 1140 | 2010 | 510 | 3660 | 4560 |
| 228 Total | | 24730 | 7570 | 1900 | 2710 | 790 | 5400 | 12060 |
| 229 - 01 | 1440 | 1170 | 390 | 960 | 7600 | 100 | 8660 | 580 |
| 02 | 1456 | 10520 | 3260 | 560 | 990 | 540 | 2090 | 5210 |
| 229 Total | | 11690 | 3650 | 1520 | 8590 | 640 | 10750 | 5790 |

HARTFORD AREA TRAFFIC STUDY

1965 BASIC DATA 1965



| Zone | | Popu- | Labor | Employment | | | | Car Owner- |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | lation | Force | Service | Mfg. | Retail | Total | ship |
| 301 | 1472 | 1370 | 400 | 80 | 180 | 30 | 290 | 820 |
| 312 | 1488 | 3060 | 980 | 80 | 130 | 30 | 240 | 1720 |
| 316 | 1504 | 9480 | 3130 | 110 | 1480 | 170 | 1760 | 4740 |
| 403 | 1520 | 7580 | 2500 | 160 | 120 | 160 | 440 | 3790 |
| 413 | 1536 | 8660 | 2510 | 460 | 930 | 490 | 1880 | 4340 |
| 701 | 1552 | 1870 | 560 | 80 | 140 | 50 | 270 | 1110 |
| 702 | 1568 | 3380 | 1120 | 30 | 110 | 90 | 230 | 2030 |
| 703 | 1584 | 2180 | 650 | 20 | 130 | 50 | 200 | 1320 |
| 704 | 1600 | 6800 | 2110 | 160 | 90 | 70 | 320 | 4010 |
| 705 | 1616 | 6430 | 2060 | 30 | 170 | 130 | 330 | 3880 |
| 706 | 1632 | 1860 | 600 | 30 | 80 | 30 | 140 | 1120 |
| 710 | 1648 | 3640 | 1090 | 30 | 80 | 130 | 240 | 2170 |
| 712 - 01 | 1664 | 9600 | 3260 | 850 | 1220 | 230 | 2300 | 3500 |
| 02 | 1680 | 11820 | 3660 | 460 | 770 | 570 | 1800 | 5430 |
| 712 Total | | 21420 | 6920 | 1310 | 1990 | [illegible]00 | 4100 | 8930 |
| Total Internal | | 825250 | 268670 | 96620 | 140540 | 51170 | 288330 | 360100 |
| 801 | 2000 | 479000 | | 144000 | | 47800 | 191800 | |
| 802 | 2016 | 24000 | | 7200 | | 2400 | 9600 | |
| 803 | 2032 | 48000 | | 14400 | | 4800 | 19200 | |
| 804 | 2048 | 12000 | | 3600 | | 1200 | 4800 | |
| 805 | 2064 | 48000 | | 14400 | | 4800 | 19200 | |
| 806 | 2080 | 48000 | | 14400 | | 4800 | 19200 | |
| 807 | 2096 | 48000 | | 14400 | | 4800 | 19200 | |
| 808 | 2112 | 480000 | | 144000 | | 48000 | 192000 | |
| 809 | 2128 | 48000 | | 14400 | | 4800 | 19200 | |
| 810 | 2144 | 240000 | | 71800 | | 23900 | 95700 | |
| 811 | 2160 | 36[illegible]00 | | 10800 | | 3600 | 14400 | |
| 812 | 2176 | 60000 | | 18000 | | 6000 | 24000 | |
| 813 | 2192 | 36000 | | 10800 | | 3600 | 14400 | |
| 814 | 2208 | 24000 | | 7200 | | 2400 | 9600 | |
| Total External | | 1631000 | --- | 489400 | | 162900 | 652300 | --- |
| GRAND TOTAL | | 2456250 | 268670 | 726560 | | 214070 | 940630 | 360100 |

HARTFORD AREA TRAFFIC STUDY
1975 BASIC DATA 1975

December 15, 1960
Revised March 27, 1961


| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 201 | 16 | 10720 | 3320 | 220 | 790 | 600 | 1610 | 6400 |
| 202 | 32 | 18750 | 5810 | 1770 | 3420 | 1170 | 6360 | 9450 |
| 203 - 01 | 48 | 7000 | 2170 | 460 | 670 | 190 | 1320 | 3480 |
| 02 | 64 | 5540 | 1720 | 650 | 750 | 370 | 1770 | 2790 |
| 03 | 80 | 4650 | 1490 | 100 | 0 | 0 | 100 | 2340 |
| 04 | 96 | 13040 | 4040 | 90 | 4750 | 1130 | 5970 | 6530 |
| 203 Total | | 30230 | 9420 | 1300 | 6170 | 1690 | 9160 | 15140 |
| 204 | 112 | 59220 | 18950 | 3370 | 9650 | 2580 | 15600 | 26360 |
| 205 | 128 | 3080 | 950 | 0 | 90 | 20 | 110 | 1840 |
| 206 | 144 | 6010 | 1800 | 100 | 650 | 190 | 940 | 3620 |
| 207 | 160 | 4570 | 1460 | 150 | 450 | 150 | 750 | 2670 |
| 208 - 01 | 176 | 17000 | 5440 | 2000 | 1700 | 1610 | 5310 | 9430 |
| 02 | 192 | 7000 | 1960 | 3600 | 27490 | 1350 | 32440 | 3620 |
| 03 | 208 | 9950 | 3180 | 650 | 350 | 480 | 1480 | 5420 |
| 04 | 224 | 13140 | 3680 | 840 | 0 | 450 | 1290 | 6910 |
| 05 | 240 | 10240 | 3070 | 950 | 1700 | 1310 | 3960 | 5220 |
| 208 Total | | 57330 | 17330 | 8040 | 31240 | 5200 | 44480 | 30600 |
| 209 | 255 | 9190 | 2850 | 200 | 1450 | 340 | 1990 | 5530 |
| 210 - 01 | 272 | 10620 | 3720 | 2410 | 1700 | 460 | 4570 | 5350 |
| 02 | 288 | 22970 | 7120 | 1120 | 1500 | 1250 | 3870 | 11330 |
| 210 Total | | 33590 | 10840 | 3530 | 3200 | 1710 | 8440 | 16680 |
| 211 | 304 | 27240 | 8170 | 1070 | 1850 | 1760 | 4680 | 13680 |
| 212 | 320 | 36190 | 10860 | 960 | 1160 | 2100 | 4220 | 18070 |
| 213 | 336 | 6520 | 2020 | 40 | 680 | 200 | 920 | 3920 |
| 214 - 01 | 352 | 7000 | 2520 | 1830 | 0 | 680 | 2510 | 2100 |
| 02 | 368 | 7000 | 2800 | 2770 | 0 | 720 | 3490 | 2120 |
| 03 | 384 | 5500 | 2090 | 1100 | 1130 | 440 | 2670 | 1670 |
| 04 | 400 | 3000 | 1200 | 13000 | 720 | 4510 | 18230 | 910 |
| 05 | 416 | 500 | 170 | 920 | 400 | 260 | 1580 | 150 |
| 06 | 432 | 0 | 0 | 350 | 1700 | 0 | 2050 | 150 |
| 07 | 448 | 0 | 0 | 400 | 1900 | 0 | 2300 | 350 |
| 08 | 464 | 5500 | 1700 | 790 | 220 | 380 | 1390 | 1620 |
| 09 | 480 | 8780 | 2990 | 1900 | 550 | 320 | 2770 | 2630 |
| 10 | 496 | 15000 | 4650 | 1000 | 0 | 670 | 1670 | 4500 |
| 11 | 512 | 8000 | 2800 | 2580 | 220 | 1320 | 4120 | 2420 |
| 12 | 528 | 7500 | 2620 | 1660 | 20 | 770 | 2450 | 2040 |
| 13 | 544 | 5500 | 2470 | 10550 | 700 | 4530 | 15780 | 2400 |
| 14 | 560 | 2000 | 900 | 3590 | 0 | 450 | 4040 | 800 |
| 15 | 576 | 10000 | 3500 | 1160 | 0 | 450 | 1610 | 3980 |
| 16 | 592 | 8000 | 2720 | 1750 | 250 | 740 | 2740 | 2390 |
| 17 | 608 | 3520 | 1200 | 270 | 300 | 280 | 850 | 1060 |
| 18 | 624 | 0 | 0 | 600 | 2500 | 0 | 3100 | 0 |
| 19 | 640 | 5500 | 1870 | 1130 | 100 | 320 | 1550 | 1660 |
| 20 | 656 | 8000 | 2960 | 2250 | 250 | 1880 | 4380 | 2430 |
| 21 | 672 | 6000 | 2520 | 7620 | 4950 | 540 | 13110 | 1820 |
| 22 | 688 | 5500 | 2470 | 3440 | 1760 | 40 | 5240 | 1620 |
| 23 | 704 | 16000 | 4960 | 6710 | 0 | 550 | 7260 | 4820 |
| 24 | 720 | 4500 | 1620 | 660 | 9450 | 300 | 10410 | 1340 |
| 25 | 736 | 10000 | 3800 | 1990 | 0 | 580 | 2570 | 4030 |
| 26 | 752 | 15500 | 4650 | 690 | 0 | 310 | 1000 | 4780 |
| 27 | 768 | 5500 | 1810 | 400 | 2150 | 20 | 2570 | 2460 |
| 214 Total | | 173300 | 60990 | 71110 | 29270 | 21060 | 121440 | 56250 |

# HARTFORD AREA TRAFFIC STUDY

1975 BASIC DATA 1975



| Zone | | Popu- | Labor | Employment | | | | Car |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | lation | Force | Service | Mfg. | Retail | Total | Owner-ship |
| 216 - 01 | 784 | 4680 | 1540 | 70 | 2130 | 240 | 2440 | 2010 |
| 02 | 800 | 3410 | 1130 | 280 | 2990 | 210 | 3480 | 1550 |
| 03 | 816 | 15840 | 5230 | 1950 | 550 | 650 | 3150 | 7890 |
| 04 | 832 | 17270 | 5700 | 380 | 0 | 730 | 1110 | 8780 |
| 05 | 848 | 4170 | 1380 | 2110 | 420 | 1040 | 3570 | 2490 |
| 06 | 864 | 8310 | 2740 | 120 | 0 | 510 | 630 | 4980 |
| 216 Total | | 53680 | 17720 | 4910 | 6090 | 3380 | 14380 | 27700 |
| 217 | 880 | 2920 | 880 | 120 | 80 | 140 | 340 | 1760 |
| 218 - 01 | 896 | 2850 | 1000 | 2210 | 950 | 2720 | 5880 | 840 |
| 02 | 912 | 11260 | 3940 | 1180 | 950 | 300 | 2430 | 3470 |
| 03 | 928 | 9870 | 3450 | 740 | 3300 | 330 | 4370 | 2900 |
| 04 | 944 | 2830 | 990 | 360 | 3600 | 120 | 4080 | 850 |
| 05 | 960 | 4280 | 1500 | 410 | 5540 | 160 | 6110 | 2590 |
| 06 | 976 | 15130 | 5300 | 750 | 1250 | 180 | 2180 | 6110 |
| 07 | 992 | 16940 | 5930 | 590 | 250 | 230 | 1070 | 6390 |
| 08 | 1008 | 12150 | 4250 | 400 | 3370 | 160 | 3930 | 4850 |
| 09 | 1024 | 12830 | 4490 | 310 | 450 | 190 | 950 | 5060 |
| 218 Total | | 88140 | 31730 | 6950 | 19660 | 4390 | 31000 | 33060 |
| 219 - 01 | 1040 | 6000 | 1860 | 490 | 600 | 250 | 1340 | 2980 |
| 02 | 1056 | 5000 | 1600 | 560 | 3470 | 290 | 4320 | 2480 |
| 03 | 1072 | 6900 | 2210 | 310 | 600 | 360 | 1270 | 3440 |
| 04 | 1088 | 7000 | 2170 | 700 | 0 | 430 | 1130 | 3470 |
| 05 | 1104 | 11760 | 3650 | 660 | 770 | 850 | 2280 | 5870 |
| 219 Total | | 36660 | 11490 | 2720 | 5440 | 2180 | 10340 | 18240 |
| 220 | 1120 | 21910 | 6790 | 590 | 6410 | 1190 | 8190 | 10690 |
| 221 - 01 | 1136 | 3980 | 1350 | 110 | 900 | 190 | 1200 | 1980 |
| 02 | 1152 | 7440 | 2230 | 480 | 700 | 330 | 1510 | 3730 |
| 221 Total | | 11420 | 3580 | 590 | 1600 | 520 | 2710 | 5710 |
| 222 | 1168 | 16210 | 5030 | 590 | 940 | 1090 | 2620 | 9710 |
| 223 | 1184 | 28710 | 8900 | 940 | 9460 | 1390 | 11790 | 14320 |
| 224 | 1200 | 19400 | 6010 | 260 | 820 | 1110 | 2190 | 9700 |
| 225 | 1216 | 8000 | 2400 | 100 | 640 | 220 | 960 | 4770 |
| 226 - 01 | 1232 | 1430 | 730 | 50 | 0 | 50 | 100 | 720 |
| 02 | 1248 | 36500 | 12410 | 1750 | 0 | 1940 | 3690 | 18400 |
| 03 | 1264 | 500 | 160 | 2710 | 0 | 1100 | 3810 | 250 |
| 04 | 1280 | 19000 | 5700 | 630 | 0 | 870 | 1500 | 9020 |
| 05 | 1296 | 21000 | 6930 | 860 | 0 | 660 | 1520 | 10350 |
| 06 | 1312 | 2500 | 820 | 1420 | 8650 | 210 | 10280 | 1250 |
| 07 | 1328 | 1950 | 580 | 60 | 0 | 60 | 120 | 980 |
| 226 Total | | 82880 | 27330 | 7480 | 8650 | 4890 | 21020 | 40970 |
| 227 - 01 | 1344 | 4000 | 1200 | 160 | 0 | 90 | 250 | 2020 |
| 02 | 1360 | 14270 | 4420 | 1960 | 1160 | 690 | 3810 | 7170 |
| 03 | 1376 | 9250 | 2770 | 130 | 950 | 450 | 1530 | 4600 |
| 227 Total | | 27520 | 8390 | 2250 | 2110 | 1230 | 5590 | 13790 |
| 228 - 01 | 1392 | 10000 | 3100 | 210 | 560 | 390 | 1160 | 5010 |
| 02 | 1408 | 11180 | 3470 | 710 | 410 | 340 | 1460 | 5590 |
| 03 | 1424 | 23500 | 7050 | 1340 | 5410 | 1660 | 8410 | 11770 |
| 228 Total | | 44680 | 13620 | 2260 | 6380 | 2390 | 11030 | 22370 |
| 229 - 01 | 1440 | 1260 | 420 | 980 | 11500 | 110 | 12590 | 620 |
| 02 | 1456 | 11050 | 3430 | 710 | 1190 | 580 | 2480 | 5500 |
| 229 Total | | 12310 | 3850 | 1690 | 12690 | 690 | 15070 | 6120 |

| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 301 | 1472 | 1400 | 410 | 80 | 180 | 30 | 290 | 840 |
| 312 | 1488 | 3130 | 1000 | 70 | 130 | 40 | 240 | 1890 |
| 316 | 1504 | 10340 | 3410 | 160 | 1480 | 240 | 1880 | 5210 |
| 403 | 1520 | 9050 | 2990 | 200 | 110 | 280 | 590 | 4530 |
| 413 | 1536 | 11530 | 3340 | 580 | 1380 | 720 | 2680 | 5760 |
| 701 | 1552 | 2200 | 660 | 90 | 390 | 80 | 560 | 1330 |
| 702 | 1568 | 4600 | 1520 | 50 | 380 | 190 | 620 | 2770 |
| 703 | 1584 | 2250 | 670 | 20 | 130 | 60 | 210 | 1360 |
| 704 | 1600 | 7500 | 2320 | 170 | 340 | 130 | 640 | 4520 |
| 705 | 1616 | 7580 | 2430 | 50 | 640 | 230 | 920 | 4580 |
| 706 | 1632 | 2000 | 640 | 30 | 290 | 40 | 360 | 1230 |
| 710 | 1648 | 4710 | 1410 | 50 | 320 | 210 | 580 | 2830 |
| 712 - 01 | 1664 | 9790 | 3330 | 900 | 1600 | 240 | 2740 | 4490 |
| 02 | 1680 | 19960 | 6190 | 650 | 2170 | 1230 | 4050 | 9840 |
| 712 Total | | 29750 | 9520 | 1550 | 3770 | 1470 | 6790 | 14330 |
| Total Internal | | 1026420 | 332810 | 126410 | 180580 | 67300 | 374290 | 480300 |
| 801 | 2000 | 596400 | | 179000 | | 59600 | 238600 | |
| 802 | 2016 | 30000 | | 8900 | | 3000 | 11900 | |
| 803 | 2032 | 59600 | | 17900 | | 6000 | 23900 | |
| 804 | 2048 | 14900 | | 4470 | | 1500 | 5970 | |
| 805 | 2064 | 59600 | | 17900 | | 6000 | 23900 | |
| 806 | 2080 | 59600 | | 17900 | | 6000 | 23900 | |
| 807 | 2096 | 59600 | | 17900 | | 6000 | 23900 | |
| 808 | 2112 | 596400 | | 179000 | | 59600 | 238600 | |
| 809 | 2128 | 59600 | | 17900 | | 6000 | 23900 | |
| 810 | 2144 | 298200 | | 89000 | | 30000 | 119000 | |
| 811 | 2160 | 44700 | | 13400 | | 4470 | 17870 | |
| 812 | 2176 | 74600 | | 22400 | | 7500 | 29900 | |
| 813 | 2192 | 44700 | | 13400 | | 4470 | 17870 | |
| 814 | 2208 | 30000 | | 8900 | | 3000 | 11900 | |
| Total External | | 2027900 | --- | 607970 | | 203140 | 811110 | |
| GRAND TOTAL | | 3054320 | 332810 | 914960 | | 270440 | 1185400 | 480300 |

HARTFORD AREA TRAFFIC STUDY
1990 BASIC DATA 1990

| Zone: Town Code | Zone: Comp. Code | Population | Labor Force | Employment: Service | Employment: Mfg. | Employment: Retail | Employment: Total | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| 201 | 16 | 25000 | 7750 | 610 | 1870 | 1740 | 4220 | 14970 |
| 202 | 32 | 44060 | 13700 | 2370 | 6490 | 3200 | 12060 | 22040 |
| 203 - 01 | 48 | 7000 | 2160 | 620 | 2170 | 190 | 2980 | 3480 |
| 02 | 64 | 6000 | 1860 | 760 | 1450 | 660 | 2870 | 3010 |
| 03 | 80 | 8000 | 2560 | 240 | 0 | 0 | 240 | 4000 |
| 04 | 96 | 24000 | 7440 | 650 | 7880 | 1960 | 10490 | 12010 |
| 203 Total | | 45000 | 14020 | 2270 | 11500 | 2810 | 16580 | 22500 |
| 204 | 112 | 70000 | 22400 | 5390 | 10950 | 3430 | 19770 | 31580 |
| 205 | 128 | 3840 | 1190 | 10 | 90 | 80 | 180 | 2300 |
| 206 | 144 | 10050 | 3015 | 160 | 1170 | 510 | 1840 | 6010 |
| 207 | 160 | 19330 | 6185 | 140 | 1330 | 1420 | 2890 | 11540 |
| 208 - 01 | 176 | 17000 | 5440 | 3170 | 1700 | 1600 | 6470 | 9180 |
| 02 | 192 | 7000 | 1960 | 4190 | 27490 | 1510 | 33190 | 3490 |
| 03 | 208 | 11000 | 3520 | 1020 | 350 | 860 | 2230 | 5470 |
| 04 | 224 | 21500 | 6130 | 1120 | 0 | 550 | 1670 | 12130 |
| 05 | 240 | 13500 | 4050 | 1780 | 1700 | 1620 | 5100 | 6850 |
| 208 Total | | 70000 | 21100 | 11280 | 31240 | 6140 | 48660 | 37120 |
| 209 | 256 | 15600 | 4840 | 300 | 2620 | 850 | 3770 | 9380 |
| 210 - 01 | 272 | 12220 | 4280 | 2530 | 1800 | 590 | 4920 | 6160 |
| 02 | 288 | 31450 | 9750 | 1530 | 4080 | 1930 | 7540 | 15550 |
| 210 Total | | 43670 | 14030 | 4060 | 5880 | 2520 | 12460 | 21710 |
| 211 | 304 | 35000 | 10500 | 2540 | 4000 | 2380 | 8920 | 17560 |
| 212 | 320 | 75000 | 22500 | 2300 | 2060 | 5200 | 9560 | 37520 |
| 213 | 336 | 13430 | 4160 | 100 | 1650 | 750 | 2500 | 8070 |
| 214 - 01 | 352 | 7000 | 2520 | 2350 | 0 | 680 | 3030 | 2060 |
| 02 | 368 | 7000 | 2800 | 3340 | 0 | 720 | 4060 | 2080 |
| 03 | 384 | 5500 | 2090 | 1410 | 1130 | 440 | 2980 | 1650 |
| 04 | 400 | 3000 | 1200 | 16310 | 720 | 5320 | 22350 | 890 |
| 05 | 416 | 500 | 170 | 1090 | 400 | 260 | 1750 | 150 |
| 06 | 432 | 0 | 0 | 350 | 2200 | 0 | 2550 | 200 |
| 07 | 448 | 0 | 0 | 400 | 2400 | 0 | 2800 | 400 |
| 08 | 464 | 5500 | 1710 | 1060 | 220 | 380 | 1660 | 1570 |
| 09 | 480 | 9000 | 3060 | 2120 | 550 | 340 | 3010 | 1090 |
| 10 | 496 | 15000 | 4650 | 1510 | 0 | 670 | 2180 | 4600 |
| 11 | 512 | 8000 | 2800 | 3790 | 220 | 1320 | 5330 | 2400 |
| 12 | 528 | 7500 | 2630 | 2390 | 20 | 770 | 3180 | 1660 |
| 13 | 544 | 5500 | 2470 | 14310 | 700 | 4530 | 19540 | 1650 |
| 14 | 560 | 2000 | 900 | 3960 | 0 | 450 | 4410 | 600 |
| 15 | 576 | 10000 | 3500 | 1520 | 0 | 440 | 1960 | 3990 |
| 16 | 592 | 8000 | 2720 | 2400 | 250 | 740 | 3390 | 2400 |
| 17 | 608 | 5000 | 1700 | 450 | 300 | 400 | 1150 | 1500 |
| 18 | 624 | 0 | 0 | 600 | 4500 | 0 | 5100 | 0 |
| 19 | 640 | 5500 | 1870 | 1350 | 100 | 320 | 1770 | 1650 |
| 20 | 656 | 8000 | 2960 | 3860 | 0 | 1880 | 5740 | 2420 |
| 21 | 672 | 6000 | 2520 | 8130 | 4300 | 540 | 12970 | 1850 |
| 22 | 688 | 5500 | 2480 | 3480 | 1760 | 40 | 5280 | 1680 |
| 23 | 704 | 16000 | 4960 | 7190 | 0 | 550 | 7740 | 4770 |
| 24 | 720 | 4500 | 1620 | 1570 | 8800 | 300 | 10670 | 1370 |
| 25 | 736 | 10000 | 3800 | 2530 | 0 | 580 | 3110 | 3980 |
| 26 | 752 | 15500 | 4650 | 960 | 0 | 310 | 1270 | 6150 |
| 27 | 768 | 5500 | 1820 | 590 | 2050 | 20 | 2660 | 2760 |
| 214 Total | | 175000 | 61600 | 89020 | 30620 | 22000 | 141640 | 55520 |

HARTFORD AREA TRAFFIC STUDY

1990 BASIC DATA 1990 

| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 216 - 01 | 784 | 8000 | 2640 | 230 | 4170 | 510 | 4910 | 3850 |
| 02 | 800 | 5500 | 1820 | 400 | 2990 | 380 | 3770 | 2750 |
| 03 | 816 | 20000 | 6600 | 2310 | 2050 | 980 | 5340 | 10030 |
| 04 | 832 | 21180 | 6990 | 720 | 0 | 1040 | 1760 | 10750 |
| 05 | 848 | 4500 | 1480 | 2640 | 420 | 1070 | 4130 | 2680 |
| 06 | 864 | 19660 | 6490 | 410 | 1000 | 1420 | 2830 | 11790 |
| 216 Total | | 78840 | 26020 | 6710 | 10630 | 5400 | 22740 | 41850 |
| 217 | 880 | 5600 | 1680 | 150 | 80 | 350 | 580 | 3360 |
| 218 - 01 | 896 | 3000 | 1050 | 3800 | 950 | 2730 | 7480 | 940 |
| 02 | 912 | 12500 | 4380 | 1340 | 950 | 400 | 2690 | 3840 |
| 03 | 928 | 11000 | 3850 | 930 | 3300 | 440 | 4670 | 3230 |
| 04 | 944 | 3000 | 1050 | 440 | 3600 | 130 | 4170 | 540 |
| 05 | 960 | 4500 | 1580 | 510 | 5540 | 180 | 6230 | 2710 |
| 06 | 976 | 15500 | 5430 | 780 | 1250 | 210 | 2240 | 6190 |
| 07 | 992 | 17500 | 6130 | 650 | 250 | 270 | 1170 | 7030 |
| 08 | 1008 | 13500 | 4720 | 490 | 3370 | 270 | 4130 | 5390 |
| 09 | 1024 | 14500 | 5070 | 430 | 450 | 320 | 1200 | 5790 |
| 218 Total | | 95000 | 33260 | 9370 | 19660 | 4950 | 33980 | 35660 |
| 219 - 01 | 1040 | 6000 | 1860 | 710 | 1600 | 250 | 2560 | 3000 |
| 02 | 1056 | 5000 | 1600 | 790 | 3770 | 290 | 4850 | 2490 |
| 03 | 1072 | 8000 | 2560 | 600 | 1600 | 460 | 2660 | 4010 |
| 04 | 1088 | 7000 | 2170 | 1030 | 0 | 430 | 1460 | 3490 |
| 05 | 1104 | 17000 | 5270 | 1220 | 3270 | 1270 | 5760 | 8480 |
| 219 Total | | 43000 | 13460 | 4350 | 9240 | 2700 | 16290 | 21470 |
| 220 | 1120 | 30000 | 9300 | 1520 | 6410 | 1840 | 9770 | 14940 |
| 221 - 01 | 1136 | 6960 | 2370 | 210 | 1100 | 430 | 1740 | 3470 |
| 02 | 1152 | 13000 | 3900 | 680 | 1700 | 770 | 3150 | 6490 |
| 221 Total | | 19960 | 6270 | 890 | 2800 | 1200 | 4890 | 9960 |
| 222 | 1168 | 34080 | 10560 | 1010 | 1950 | 2520 | 5480 | 20480 |
| 223 | 1184 | 50000 | 15500 | 1580 | 15810 | 3090 | 20480 | 24980 |
| 224 | 1200 | 45950 | 14240 | 900 | 1880 | 3230 | 6010 | 22940 |
| 225 | 1216 | 12790 | 3840 | 660 | 1340 | 600 | 2600 | 7640 |
| 226 - 01 | 1232 | 1500 | 450 | 80 | 0 | 60 | 140 | 750 |
| 02 | 1248 | 36500 | 12410 | 3470 | 0 | 1940 | 5410 | 18270 |
| 03 | 1264 | 500 | 170 | 3770 | 0 | 1100 | 4870 | 250 |
| 04 | 1280 | 19000 | 5700 | 1470 | 0 | 870 | 2340 | 9420 |
| 05 | 1296 | 21000 | 6930 | 1440 | 0 | 660 | 2100 | 10420 |
| 06 | 1312 | 2500 | 830 | 1610 | 8650 | 210 | 10470 | 1250 |
| 07 | 1328 | 2000 | 600 | 110 | 0 | 60 | 170 | 1000 |
| 226 Total | | 83000 | 27090 | 11950 | 8650 | 4900 | 25500 | 41360 |
| 227 - 01 | 1344 | 4000 | 1200 | 220 | 0 | 90 | 310 | 2010 |
| 02 | 1360 | 14500 | 4490 | 1870 | 2660 | 710 | 5240 | 7230 |
| 03 | 1376 | 16820 | 5050 | 380 | 1750 | 1065 | 3195 | 8390 |
| 227 Total | | 35320 | 10740 | 2470 | 4410 | 1865 | 8745 | 17630 |
| 228 - 01 | 1392 | 10000 | 3100 | 490 | 560 | 390 | 1440 | 4980 |
| 02 | 1403 | 14000 | 4340 | 2730 | 1210 | 570 | 4510 | 7000 |
| 03 | 1424 | 26000 | 7800 | 2450 | 11570 | 1860 | 15880 | 13010 |
| 228 Total | | 50000 | 15240 | 5670 | 13340 | 2820 | 21830 | 24990 |
| 229 - 01 | 1440 | 1500 | 500 | 1020 | 13500 | 130 | 14650 | 740 |
| 02 | 1456 | 13500 | 4190 | 950 | 6160 | 780 | 7890 | 6710 |
| 229 Total | | 15000 | 4690 | 1970 | 19660 | 910 | 22540 | 7450 |

| Zone | | Population | Labor Force | Employment | | | | Car Ownership |
|---|---|---|---|---|---|---|---|---|
| Town Code | Comp. Code | | | Service | Mfg. | Retail | Total | |
| 301 | 1472 | 1600 | 470 | 80 | 180 | 50 | 310 | 950 |
| 312 | 1488 | 3940 | 1260 | 80 | 130 | 100 | 310 | 2390 |
| 316 | 1504 | 13540 | 4470 | 240 | 1480 | 500 | 2220 | 6760 |
| 403 | 1520 | 14390 | 4750 | 310 | 110 | 710 | 1130 | 7300 |
| 413 | 1536 | 21880 | 6350 | 850 | 2260 | 1550 | 4660 | 10960 |
| 701 | 1552 | 3910 | 1180 | 110 | 390 | 220 | 720 | 1600 |
| 702 | 1568 | 12050 | 3980 | 110 | 930 | 790 | 1830 | 7230 |
| 703 | 1584 | 2720 | 820 | 30 | 130 | 100 | 260 | 1640 |
| 704 | 1600 | 11270 | 3490 | 200 | 820 | 430 | 1450 | 6770 |
| 705 | 1616 | 14240 | 4560 | 110 | 1530 | 760 | 2400 | 8550 |
| 706 | 1632 | 2570 | 820 | 30 | 760 | 85 | 875 | 1570 |
| 710 | 1648 | 8930 | 2680 | 100 | 790 | 550 | 1440 | 5350 |
| 712 - 01 | 1664 | 10000 | 3[illegible]00 | 980 | 2200 | 260 | 3440 | 5080 |
| 712 - 02 | 1680 | 35000 | 10850 | 1360 | 5330 | 2430 | 9120 | 17400 |
| 712 Total | | 45000 | 14250 | 2340 | 7530 | 2690 | 12560 | 22480 |
| Total Internal | | 1399560 | 447950 | 174340 | 245370 | 97935 | 517645 | 676080 |
| 801 | 2000 | 780000 | | 231700 | | 77300 | 309000 | |
| 802 | 2016 | 39000 | | 11600 | | 3900 | 15500 | |
| 803 | 2032 | 77300 | | 23200 | | 7700 | 30900 | |
| 804 | 2048 | 19300 | | 5800 | | 1900 | 7700 | |
| 805 | 2064 | 77300 | | 23200 | | 7700 | 30900 | |
| 806 | 2080 | 77300 | | 23200 | | 7700 | 30900 | |
| 807 | 2096 | 77300 | | 23200 | | 7700 | 30900 | |
| 808 | 2112 | 773000 | | 232000 | | 77000 | 309000 | |
| 809 | 2128 | 77300 | | 23200 | | 7700 | 30900 | |
| 810 | 2144 | 386400 | | 116000 | | 38600 | 154600 | |
| 811 | 2160 | 58000 | | 17400 | | 5800 | 23200 | |
| 812 | 2176 | 96600 | | 28900 | | 9700 | 38600 | |
| 813 | 2192 | 58000 | | 17400 | | 5800 | 23200 | |
| 814 | 2208 | 38600 | | 11600 | | 3900 | 15500 | |
| Total External | | 2635400 | --- | 788400 | | 262400 | 1050800 | --- |
| GRAND TOTAL | | 4034960 | 447950 | 1208110 | | 360335 | 1568445 | 676080 |